SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1915.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

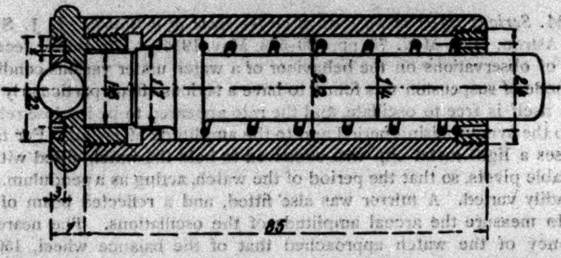
SEPTEMBER 1915.

GENERAL PHYSICS.

1164. *Serious Effect of Suspension on the Rate of a Watch.* **J. J. Shaw.** (Roy. Astron. Soc., M.N. 75. pp. 583–588, May, 1915.)—The author records a series of observations on the behaviour of a watch under various conditions. The mode of suspension was found to have a serious effect, particularly if the watch itself is free to oscillate, and the rate appeared to be in close relationship to the synchronising period and to the amplitude of swing. For testing purposes a light metal clip was contrived to hold the watch, fitted with two adjustable pivots, so that the period of the watch, acting as a pendulum, could be readily varied. A mirror was also fitted, and a reflected beam of light used to measure the arcual amplitude of the oscillations. The nearer the frequency of the watch approached that of the balance wheel, 150, the greater the gain. It was found impossible to get frequencies above 150 with the watch oscillating in the vertical plane, but by an adjustment of the pivot the rate could be tested in various angles and frequencies as high as 180 per min. were obtainable. The watch in the latter case was losing, and the nearer the balance wheel was brought into the plane of the oscillations, viz. vertical, the greater the change in rate; further, the more the frequency fell towards that of the balance wheel, the greater the loss. At 155 per min. the experiment becomes very critical, and the rate will suddenly change over from a max. loss to a max. gain, and *vice versa*, without perceptible change of frequency. The results obtained are in good accord with the theory of the double pendulum, and it is of importance to remember them if good time is to be kept. Examples from actual practice conclude the paper. H. H. Ho.

1165. *Anomalous Variations in Rigidity of Phosphor-bronze Strips.* **H. Pealing.** (Phil. Mag. 29. pp. 203–207, July, 1915.)—The variations in the torsional rigidity of phosphor-bronze strips previously noted by the author [see Abs. 904 (1913)] have been attributed to bifilar action [Abs. 1202 (1913) and 240 (1915)]. This is not in agreement with Searle's theoretical result, and the present work was undertaken to obtain experimental proof for attributing the variations observed to overstrains given to the strips during manufacture. The dimensions of the four strips used were 25 × 0·024 × 0·0012 cm., and determinations by the dynamical method of their torsional rigidity gave very irregular results. This shows, incidentally, that when a new phosphor-bronze suspension is fitted to a galvanometer the figure of merit to be expected from a strip of given dimensions cannot be predicted with any certainty. The effect of annealing the strips was practically to eliminate the variation of rigidity with change of load, and it is therefore concluded that if there is a bifilar effect in the strips it is exceedingly small and completely masked by other effects. J. W. T. W.

1166. *Hardness Tests with a Hand-operated Apparatus.* **F. Turpin.** (Rev. de Mét. 12. pp. 104–112, Feb., 1915.)—The apparatus illustrated in the accompanying diagram has been designed for the rapid determination of the hardness of metals in the workshop. It consists of a barrel carrying a plunger resting on the upper surface of a cylinder of metal whose Brinell hardness is known. In contact with the lower surface of the standard is a 10-mm. ball held in position by a suitable ring. The apparatus is used exactly like a punch ; the ball is placed in contact with the metal to be tested and the top of the plunger is struck smartly with a hammer, when impressions are made in both the standard and the metal under test. The diameters of the two impressions are then measured, and the hardness of the metal under test is calculated from the formula $\Delta_e/\Delta_m = D_m^2/D_e^2$, where Δ_m is the Brinell hardness number and D_m the diam. of the impression in the metal under test, Δ_e being the Brinell hardness number and D_e the diam. of the impression in the standard. This formula is not quite exact, since the Brinell hardness-number is not a function of the square of the diam. of the impression but of the area of the spherical cavity. Some correction is therefore necessary, and this is effected by diminishing the results obtained by 10 units. To facilitate the working out of the results a gauge has been devised for the measurement of the diam. of the cavity, and a slide rule is supplied for calculating the hardness values. The rule is provided with a scale for the conversion of the hardness values into tenacities on the basis of the formula $\Delta = R/0{\cdot}84$, where R is the tenacity in kg./mm². Experience has shown that the best results are obtained by the use of a standard made from a medium-hard or hard steel. The force of the blow exercises no influence on the magnitude of the results. F. C. A. H. L.



1167. *Brinell Hardness and Tenacity Factors of Heat-treated Special Steels.* **A. McWilliam** and **E. J. Barnes.** (Iron and Steel Inst., J. 91. pp. 125–134 ; Disc., 135–139, 1915.)—Gives the results of a series of determinations of Brinell numbers, yield-points and maximum stresses on steels containing respectively 2 % Cr., 3 % Ni, and 0·2 % V with varying carbon and after various heat-treatments, together with the calculated factors for converting the hardness number into maximum stress. The following table gives the mean results obtained for this factor:—

	2 % Chromium.	3 % Nickel.	0·2 % Vanadium.
Samples as received	0·250	0·243	0·231
Normalised samples	0·246	0·244	0·221
Drastically annealed samples	0·249	0·246	0·250
Quenched from 825° and tempered at 400°	0·240	0·238	0·240
" " " 550°	0·234	0·234	0·244
" " " 650°	0·233	0·240	0·238

The following are the mean figures obtained for steels of less than 50 tons max. stress and those of 50 tons max. stress and over :—

Chromium series.........	Less than 50 tons.........	Factor	0·243
	50 tons and over	"	0·241
Nickel series	Less than 50 tons.........	"	0·242
	50 tons and over	"	0·237
Vanadium series.........	Less than 50 tons.........	"	0·238
	50 tons and over	"	0·234

The calculated factors show a fair consistency in steels varying from 24 to 112 tons per sq. in. tenacity, with yield-points from 50 to 95 % of the max. stress. C. O. B.

1168. *Comparative Tests with the Amsler-Laffon Drop Testing-machine and a New Small Pendulum Hammer.* **A. Schmid.** (Zeits. Vereines Deutsch. Ing. 59. pp. 423–426, May 22, 1915.)—A complete series of comparative impact tests made with these two machines has shown that the results are in very close agreement with each other. The small pendulum hammer made by Mohr and Federhaff of Mannheim is eminently adapted for works' laboratories because it is relatively low in first cost, takes up very little space, is easy to manipulate and gives results rapidly, and can be readily adapted to the testing of specimens of various dimensions. As a result of two years' experience in the making of impact bending tests the author has come to the conclusion that these tests should be made on specimens of large dimensions—if possible, approximating to the size in which the material is to be used. Small test-pieces may indicate that a material is very tough in confirmation of a satisfactory composition and microstructure, but in the dimensions used in constructional purposes the desired resilience may be destroyed by the existence of internal stresses. F. C. A. H. L.

1169. *Stress-Strain Loops for Steel in the Cyclic State.* **J. H. Smith** and **G. A. Wedgwood.** (Iron and Steel Inst., J. 91. pp. 365–397, 1915.)—Experimental work on the fatigue of steel has been continued by subjecting test-pieces to a given alternating stress-range and simultaneously-applied mean stresses which were varied between certain limits. Under these conditions it has been found that the mean strain is proportional to the mean stress up to a certain point, just as in the ordinary static tests. Beyond this point there is a distinct yield, and the ranges determined in this manner are spoken of as the "yield ranges." It has already been suggested in an earlier paper that these yield ranges are identical with the Wöhler limiting ranges, and the method therefore provides a rapid way of determining values which can only be determined otherwise by a prolonged series of experiments. A material is said to be in the cyclic state when its yield-stresses in tension and compression are equal. The results of a large number of experiments carried out on very mild steels indicate that the effect of yield is to lower the Bauschinger range. During a period of rest the Bauschinger range gradually recovers ; the material always returns to the primitive state, and in certain cases may even become harder than it was in the primitive state. In the primitive state this range is always unstable. If a material be subjected to alternating stress whose mean value is other than zero and yield does not occur, then the alternating stress-range is an elastic one, but if a yield occurs the range is not elastic. For a given mean stress the yield range is the max. possible elastic range for that mean stress. F. C. A. H. L.

1170. *Example of Persistent Fragility in a Steel.* **V. Bernard** and **A. Portevin.** (Rev. de Mét. 12. pp. 155–160, March, 1915.)—The authors have had occasion to examine a semi-hard steel forging which fractured in service. Microscopic examination showed the existence of two zones, one in which the grain size was small and the other in which the grain size was very large, indicating that the steel had been maintained for a long time in the temperature interval which Belaiew has designated the "zone of granulation." A shock test on a notched bar showed that the resilience was equal to only 4·5 kg.-cm.^{2}. After restoration by quenching in water from 850° C. followed by annealing at 700° C., the resilience figure was found to be unaltered, showing that the trouble was not due simply to grain-size. Careful microscopic examination of the areas in which the grain-size was small indicated that there was a large network of ferrite grains superimposed on the smaller structure. Under higher magnifications, lines of holes were observed running through the centre of the ferrite forming the boundaries of the large grains. These lines of holes form the traces of an earlier crystallisation in large grains and explain the fragility of the material, which could not be removed by the usual processes of restoration. F. C. A. H. L.

1171. *Change in Density of Mild Steel Strained by Compression beyond the Yield-point.* **F. C. Lea** and **W. N. Thomas.** (Engineering, 100. pp. 1–3, July 2, 1915.)—The results of a series of experiments made by the authors show that when mild steel is caused to flow by compression the density is diminished. The density-stress curve is a parabola whose equation is represented by the formula $\delta = 0{\cdot}9984 + 29 \times 10^{-9}(250 - s)^2$, where δ is the relative density and s the stress in tons per sq. in. calculated on the original area. In the course of time the density tends to revert to its original value.

F. C. A. H. L.

1172. *The Impact Test and the Law of Similarity.* **R. Stribeck.** (Zeits. Vereines Deutsch. Ing. 59. pp. 57–60, Jan. 16, 1915.)—At the Copenhagen Congress of the International Association for the Testing of Materials in 1909, it was concluded that the specific resilience of a material was independent of the size of the test-piece so long as the bars were proportionally dimensioned. The author takes exception to this conclusion, and shows that according to the law of similarity the impact energy should vary as the cube of the size of the bars and, therefore, a bar of 1/3 the linear dimensions should only have 1/27 the resilience of the normal bar. The results of tests on various classes of steel in bars of proportional dimensions carried out in a Charpy pendulum hammer show that in every case the specific resilience of the small bar was lower than that of the large bar by 20 to 50 %. With all materials a greater amount of work than is demanded by the law of similarity is necessary to effect the fracture of the smaller proportional bar. This proves that not only is the conclusion arrived at by the International Association erroneous, but also that the law of similarity does not apply to impact testing. The author ascribes this to the fact that the structures of the bars are equal instead of proportional. During the tests it was established that the velocity of the blow had no perceptible influence on the results. Measurements of the deformation showed that the small bars underwent a greater specific deformation than the large bars. The conclusion drawn from this work is that it is essential to adopt one standard-sized bar for carrying out impact tests. On account of the large bar (8 cm.) showing greater differences between various classes of material, it is to be preferred for the standard. F. C. A. H. L.

1173. *Variation with Temperature of the Elasticity of Metals and Alloys from 20° C. to near their Melting-points.* **K. R. Koch** and **C. Dannecker.** (Ann. d. Physik, 47. 2. pp. 197–226, June 1, 1915.)—Describes experiments on the torsional elasticity of wires at various temperatures. The pure metals investigated were Al, Fe, Ni, Cu, Zn, Pd, Ag, Cd, Sn, Pt, Au, and Pb, while various alloys were also used, including specimens of nickelin, manganin, phosphor-bronze, and Al-bronze. The wires employed for the experiments were about 380 mm. long and 1·5 mm. in diam. These were suspended together with the moving weight in an air-proof chamber in which the pressure was reduced to 1–2 mm. Particular care was taken to exclude oxygen on account of its action on the metal surfaces at the high temperatures attained. The method of heating employed was electrical, temperatures from 20° C. up to the neighbourhood of the melting-points of the various metals being investigated (in the case of Pt a measurement was made at 1700° C.). The temperatures were measured at first by an optical pyrometer, but this method was supplemented by the use of a thermo-element attached to the centre of the experimental wire. The distribution of temperature along the wire which corresponded to any particular mid-point temperature was determined by separate experiments, and from (i) the results obtained from the observations of the swings and (ii) this knowledge of the temperature distribution of the wire, it was possible to deduce the torsion modulus at each temperature. These moduli are tabulated in the paper, and are also exhibited graphically. Allowance was made for the low reading of the thermo-element owing to its cooling effect on the wire. This correction is also increased by any uncertainty in the contact between the two. Comparison of temperatures as measured by the element and by the optical pyrometer shows that this difference increases with rise of temperature.
J. W. T. W.

1174. *Observation of the Dissipation of the Shock Energy and Determination of the Energy of Deformation during Shock-crushing Tests.* **H. Seehase.** (Zeits. Vereines Deutsch. Ing. 58. pp. 1345–1348, Aug. 22, 1914.)—Observation of the behaviour of metals above their elastic limits shows that the rate of deformation exerts an influence on the magnitude of the stresses developed during the deformation. In the ordinary tensile test the rates of deformation are too small to give any idea of the behaviour of the material in such working appliances as presses and power hammers. The author has therefore fitted to an impact testing-machine of the falling weight type an appliance for photographically recording the movement-time curve of the tup during the period of impact. From the curve obtained the energy of deformation can be calculated. Static compression tests were carried out on the same materials and the results compared. The comparison shows that in copper, brass, steel, and rivet iron the behaviour under shock-crushing is quite different from that under slow compression. In copper, steel, and iron the amount of energy required to produce equal compression is much greater in shock-crushing than compression tests. The hardness of a copper cylinder after shock-crushing is always greater than that of a similar cylinder slowly compressed by an equal amount.

F. C. A. H. L.

1175. *Longitudinal Impact of Cylindrical Rods.* **W. Voigt.** (Ann. d. Physik, 46. 5. pp. 657-676, March 16, 1915.)—The usual theory of the impact of rods supposes an instantaneous compression resulting in an elastic rebound which causes the separation of the bodies. At the instant of compression the two bodies are considered to be intimately connected. This theory has been found not to agree accurately with the results of experiment, as, for instance, in the case of the impact of two similar rods where the theory demands that the velocities of the rods shall be exchanged at impact. It is found in practice that if one rod is initially at rest, the second, after impact, *follows* it slowly. The author supposes that the theory is inexact owing to bending and imperfect polish of the impacting surfaces, layers of condensed gases, etc., resulting in inequality of pressure over the surfaces of contact. He therefore postulates the presence of an "intermediate layer" of material which is alone compressed according to a different law and by the dilatation of which the rods are subsequently separated. His deductions on this theory agree more closely with experiment than those founded on the usual mechanical theory.

J. W. T. W.

1176. *Superficial Deformation of Steels Quenched from Relatively Low Temperatures.* **B. Bogitch.** (Comptes Rendus, 160. pp. 768–771, June 14, 1915.)—The author has confirmed the earlier observations of Zschokke on the appearance of undulations on the polished surface of specimens of steel after quenching from temperatures between 225° and 400° C. Using specimens 4 cm. square by 1·1 cm. in thickness it was found that undulations first made their appearance on quenching from temperatures in the neighbourhood of 215°–220° C.; they increased in width as the temperature rose, and disappeared completely when the temperature of quenching was above 360° C. It was found that as the temperature of the quenching water rises, the temperature interval in which undulations can be obtained is diminished; in fact no markings were obtained on samples quenched in boiling water. The duration of heating is of considerable importance in determining the structure obtained at any temperature, as also is the size of the sample. Samples less than 1 cm. square gave no surface marking on quenching. After once quenching the sample was found to have lost its property of producing undulations, and the property could only be restored by annealing from temperatures above 700° C.

F. C. A. H. L.

1177. *Diffusion of Gases at Low Pressures made Visible by Colour Effects.* **C. T. Knipp.** (Science, 42. pp. 93–94, July 16, 1915.)—A visible electric discharge is obtained through air, the characteristic colour of the discharge being orange-red. A reservoir, connected with the end of the discharge tube, contains a gas having a different characteristic colour. In the experiment described illuminating gas was used. The pressure in the reservoir is arranged so that on opening the connecting tap the end of the discharge tube is filled with the greenish-white characteristic colour of illuminating gas, which slowly diffuses throughout the tube. T. H.

1178. *Diffusion of Gases through Mercury-vapour at Low Pressures, and the Diffusion Air-pump.* **W. Gaede.** (Ann. d. Physik, 46. 3. pp. 357–392, Feb. 12, 1915.)—A knowledge of gaseous diffusion through Hg-vapour is of special importance for estimating the lowest pressures which can be obtained by mercury air-pumps. Opinions as to the nature of these very reduced pressures as measured by a McLeod manometer are very conflicting, for alongside a belief in their reality we find the view that it is impossible to obtain a total pressure less than about 0·0013 mm., which is in the vicinity of the vapour tension of the mercury in the pump. To obtain more exact data on this problem, the author has devised an apparatus to investigate the dynamical equilibrium between dilute gases and Hg-vapour, comprehensive details of which are given with illustrations and tables of measurements. Curves show that relationships *in vacuo* are quite different from those existing at higher pressures, and a theoretical investigation into the nature of the diffusion constants follows these vacuum experiments. The influence of diffusion upon the production and measurement of very low pressures next receives experimental attention, when it is found that vacua can be produced by mercury pumps and measured with the McLeod gauge when the total pressure in the evacuated compartment is appreciably smaller than the tension of Hg-vapour. The practical application of diffusion to the production of a mechanical suction is described in great detail, and is followed by a mathematical investigation of the simultaneous passage of gas and vapour through a narrow opening. Finally details are given as to the construction and manipulation of a diffusion air-pump. The results of this work are briefly summarised as follows:—The mutual permeation of gases and Hg-vapour has been experimentally established at reduced pressures, and the Stephan diffusion equation for an equilibrium state found to agree with the facts. The experiments have shown that with a mercury pump a total pressure can be produced in a vessel which is much lower than the total pressure remaining in the pump compartment, if the tubes which connect the pump with the evacuated vessel are cooled. The current text-book statement that with a mercury pump no lower pressure can be produced than the vapour tension of the Hg in the pump, has not only been found fallacious, but that on the contrary the diffusion procedure can so be regulated that almost any desired pressure can be attained, and a pump involving these principles has been designed. A most simple diffusion air-pump is afforded by a closed earthenware cylinder surrounded by air-free steam, which thus diffuses from without into the cylinder while the air within diffuses in the opposite direction. If the steam condenses inside the cylinder then the pressure within sinks gradually from 740 mm. to 15 mm. By combining such an earthenware membrane with a water-pump it has been found possible to evacuate a Röntgen tube so highly as to allow of the production of Röntgen rays. In the diffusion pump itself the clay membrane is replaced by a steel cylinder, since the former only acts slowly. The steel cylinder is provided with one or several apertures so arranged that their dimensions are of the same order as the free paths of the molecules. Mercury is used instead of water on account of the much smaller vapour-pressure. In this way it has been possible to construct a diffusion pump which possesses not only the same average suction speed as a rotating mercury pump designed earlier by the author [Abs. 1768 (1913)], but has the advantage of evacuating both gases and vapours, with the exception of mercury; if the Hg-vapour be frozen out then this apparatus gives a higher vacuum than any known air-pump. H. H. Ho.

1179. *Possibility of deriving Gravitation as Immediate Consequence of Relativity of Inertia.* **H. Reissner.** (Phys. Zeits. 16. pp. 179–185, May 1 and 15, 1915.)—Mechanics treats inertia and weight as independent phenomena, and apprehends inertia as a resistance towards acceleration in absolute space. The fact that both forces are proportional to mass and have the same dimensions is regarded as accidental, despite the fact that physics has not yet explained the dimensions of the gravitational constant. On this subject the work of Mach, Abraham, and Mie, is briefly reviewed. The author now continues his work on the relativity of acceleration, approaching the present problem from the standpoint of the opposing forces in centrifugal force and making these responsible for gravitation. The latter is thus explained as the immediate and necessary consequence of relative acceleration; the identity between heavy and inert mass rendered obvious; and the gravitation field not only shown equivalent to an accelerated medium, but the force of gravity itself proved identical with a resistance towards relative acceleration. The following principles are established: (1) That the mechanical force of inertia is the resultant resistance towards translatory accelerations of a mass relative to all other masses in space. (2) Weight or Newtonian gravitation is the inertia force of the rotation of mass particles about each other. Other conclusions arrived at are: The simplification of an earlier expression for the kinetic energy of masses so that gravitational action appears as one of pure inertia and does not involve potential energy; here the hypothesis is necessary that all rotating masses possess a gravitation field, the axes of rotation being irregularly directed and distributed. Inert mass is found to be only approximately a scalar quantity on this hypothesis, and this when a sufficiently symmetrical distribution of mass in the universe is assumed. Attracting masses are likewise equally dependent on the general mass-distribution. While the general expression of the elementary law for the problem of two masses appears to correspond to a tensor theory of inertia and gravitation, yet the assumption of a certain symmetry of mass distribution and rotation requires a scalar theory of gravitation, and, by the aid of a Lagrangian function, the phenomenon known as action at a distance can be explained. There also follows the conclusion that an enlargement of inert mass, and a decrease in light-velocity and in energy, ensues when masses approach. H. H. Ho.

1180. *Molecular Gas-resistance on a Moving Plate.* **M. Knudsen.** (Ann. d. Physik, 46. 5. pp. 641–656, March 16, 1915.)—The author theoretically finds that the ratio y of the gas resistances to a moving plate, normally and tangentially, should lie between 8·7777 and 8·5708. Experimentally, by oscillating a plate suspended by a quartz fibre in the two positions, he finds for bright Pt in various gases the following values for y:—

	Hydrogen.	Oxygen.	Carbon dioxide.	Argon.	Helium.
$y =$	8·85	8·74	8·71	8·80	8·90

[See Abs. 899 (1911).] E. H. B.

1181. *Theory of the Air-resistance Law.* **L. Grebe.** (Phys. Zeits. 16. pp. 87–88, March 1, 1915.)—Should an air-current impinge vertically on a plane surface, or should a plane surface move in still air in a perpendicular direction, then experiment has demonstrated the presence of a resistance proportional to the area of the moving surface and to the square of its velocity. The author finds the theoretical treatment of this experimental law to be inadequate, and the present note is a discussion on theoretical lines taking into account the air displacement at the rear of the moving surface and the frictional consequences involved. When the thickness of the replaced layer at the rear is made dependent on the velocity, then the law $K = \text{const.}\ v^2 F \eta$ is obtained from the more general expression

$$K = Fv\eta\pi/2/\sqrt{Cd_0}$$

by putting $d_0 = c/v^2$, where K is the frictional force, F the surface area, v the velocity, η the viscosity coefficient, C and c are constants, and d_0 is the thickness of the replaced layer. H. H. Ho.

1182. *Maxwell Distribution Law in Newtonian and non-Newtonian Mechanics.* **G. N. Lewis** and **E. Q. Adams.** (Phys. Rev. 5. pp. 510–521, June, 1915.)—Offers an independent method of deriving the distribution—in the non-Newtonian as well as in the Newtonian case—a method which, so far as the authors can see, is as rigorous as the fundamental principles of mechanics and geometry on which it is based. For the non-Newtonian case use is made of the "Space-Time Manifold of Relativity" [see Abs. 848 (1911), 7 (1915)]. E. H. B.

1183. *Local Differences of Pressure near an Obstacle in Oscillating Water.* **[Mrs.] H. Ayrton.** (Roy. Soc., Proc. 91. pp. 405–410, July 1, 1915.)—In a former paper [Abs. 1676 (1910)] the author showed that when a barrier fits tightly against the sides and across the bottom of a vessel of oscillating water (1) a vortex forms against each side of the barrier in turn as it becomes the lee side; (2) this vortex never forms while the water is attaining to the mean level, but only while it is falling below and rising above that level. It was then suggested that such vortices were due to the conjunction of the main stream flowing over the barrier with opposing local streams created by local pressure-differences set up in the neighbourhood of the barrier by the oscillating water. Exception was taken to this explanation, and also, later, to the experimental evidence put forward. The object of the present paper is to give an account of further experiments carried out for this same purpose, with pressure indicators free from the objections urged against the thin gutta-percha diaphragms used earlier—namely: that they themselves might cause variations in the distribution of pressure. The pressure indicators and their method of use are fully described, as is also the construction of the obstacle employed. Diagrams accompany the descriptions. Instantaneous photographs are giving showing the oscillations of the water during the first part of a swing from left to right, during the second part of one in the same direction, and while the water swung from right to left. [Each half-oscillation, or swing of the water in one direction, was called a swing; the time during which the water approaches the mean-level position was called the first part of the swing, and that during which it departs from the level the second part.] The conclusions drawn are:—(1) When the water is approaching the mean level there is a diminution of pressure, or partial vacuum, created in the lee of the obstacle. (2) When the water is departing from the mean level the diminution of pressure continues high up on the lee side, but over the lower part there is a pressure in the opposite direction to that of the main stream. (8) The jet in the first part of a swing is due to the local current created by the local difference of pressure; the vortex in the second part of the swing is due to the conjunction of the main stream with the opposing local current set up by the local pressure-difference. H. H. Ho.

1184. *Amplitude Relations of Rayleigh's Surface Waves.* **C. Mainka.** (Phys. Zeits. 16. pp. 117–121, April 1, 1915.)—The Rayleigh waves are confined to the terrestrial surface, and were assumed to be harmonic, the earth, its surface and interior, being regarded as one isotropic system. Rudzki, on the other hand, postulates transverse isotropy for the upper layers of the crust, and has worked out axial relationships on this assumption. For correct investigation of these theories the present author recommends the comparison of the long waves recorded in the seismographs of three stations lying not too far apart, *i.e.* the so-called seismic triangulation of Omori. Tables of data are given to illustrate agreement between the mathematical results here obtained by the author and experimental observations, and the main conclusion drawn is that in the wave train recorded by seismographs, the majority of the waves are of the Rayleigh character and possess a velocity smaller than the transverse waves. Axial relationships are given in the paper. H. H. Ho.

1185. *Contributions to Hydrodynamics.*—II. **C. W. Oseen.** (Ann. d. Physik, 46. 5. pp. 623–640, March 16, 1915.)—In Part I [see Abs. 974 (1915)] the author showed how the system—

$$\begin{cases} \rho\,\partial u/\partial t = -\partial p/\partial x + \mu\Delta u, \\ \rho\,\partial v/\partial t = -\partial p/\partial y + \mu\Delta v, \\ \rho\,\partial w/\partial t = -\partial p/\partial z + \mu\Delta w, \\ \partial u/\partial x + \partial v/\partial y + \partial w/\partial z = 0 \end{cases}$$

can be solved when μ has a very small positive value. The important result derived from this solution was that if the above system be the equations of motion of a fluid, then with a disappearing μ the latter behaves quite differently in the rear of a rigid body to what it does in front. At the latter the fluid slips, at the former it adheres, and the subsequent motion is, as a rule, one of eddies. It is possible to realise these facts experimentally by the motion of a body in a slightly viscous fluid, but a more severe problem is to give a rigid mathematical treatment of the subject. The author has previously attempted this for a special case, and now transforms the complete hydrodynamic equations into a system of integro-differential equations from which he draws conclusions as to the motion. First, the case of a body moving with positive velocity parallel to a straight line is considered, then the conditions behind and in front of an infinitely long cylindrical body moving with constant velocity through a frictionless fluid-receive attention. Prandtl has asserted that friction only exerts its influence on the motion of a slightly viscous fluid in the neighbourhood of a body. The present author opines that the friction is much more negligible in the vicinity of the body than more remotely, while behind the body it becomes of paramount importance. A mathematical investigation of this influence then follows. The paper concludes with a brief review of the different theories of liquid resistance proposed by Green-Dirichlet, Helmholtz-Kirchhoff, Prandtl, and Karmán.

Part III (Ann. d. Physik, 46. 8. pp. 1130–1150, April 30, 1915) contains a mathematical investigation of the Stokes-Navier differential equations. From it the author concludes that singularities can occur in the solution for the equations of motion of a viscous fluid, which are expressed hydrodynamically as systems of eddies. **H. H. Ho.**

1186. *Dynamics of Continuous Systems.* **G. D. Mattioli.** (N. Cimento, 9. pp. 255–262, March–April, 1915.)—Mathematical. Gives transformations of the fundamental equations, which bring in energy and the flux of energy. **A. D.**

1187. *Drops under Periodic Forces.* **K. Boedeker.** (Ann. d. Physik, 46. 4. pp. 503–546, Feb. 26, 1915.)—An elaborate experimental research illustrated by fourteen graphs and diagrams and twenty-seven instantaneous photographic records of the pulsating drops, etc. The drops were set in vibration by periodic electric forces, and arrangements were made by which they could be photographed at different instants. By a modification of the apparatus the upper vibrations, or overtones, could be obtained also. To avoid electrostatic disturbances vibrations were also produced by mechanical forces. This led to a convenient method of measuring the surface tension of the interface of two liquids of like density.

The influence of a pulsating drop on one at rest was also investigated, thus giving an extension of Bjerknes' work in hydrodynamic attractions and repulsions.

The experiments were finally extended to emulsions of electrically conducting droplets in an insulating medium. **E. H. B.**

1188. *Surface Tension by the Bubble Method.* **E. Schrödinger.** (Ann. d. Physik, 46. 3. pp. 413–418, Feb. 12, 1915.)—The surface tension of a liquid may be determined from a knowledge of the excess pressure in an air-bubble when it escapes from the end of a vertical tube of circular cross-section immersed in the liquid. Cantor [Ibid. 47. p. 413, 1892] has developed a formula for this case and gives $a^2 = rh[1 - 2r/3h - r^2/3h^2]$. Here $a^2 =$ specific cohesion $= 2\tau/\rho g$ [$\tau =$ surface tension $\rho =$ density of liquid], $r =$ radius of mouth of tube, $h =$ pressure at which the bubble escapes less the hydrostatic pressure at the opening of the tube [expressed as head of liquid]. Feustel [Abs. 931 (1905)] gives $a^2 = rh[1 - 2r/3h - r^2/h^2]$. Recently Ferguson [Abs. 1655 (1914)] has dealt with the same problem. His result reduces to

$$a^2 = rh[1 - 2r/3h + (r/h)^{3/2}/\sqrt{6}].$$

The author considers the third term in the brackets to be wrong in each of the above cases. Commencing with the fundamental equations for the height of ascent of a liquid in a capillary tube and of the section of the meniscus made by a median vertical plane as given in Winkelmann's *Handbuch der Physik* [vol. i. p. 1144] he obtains $a^2 = rh[1 - 2r/3h - r^2/6h^2]$. The author points out that the experimental confirmation of the Feustel formula by Martin, using the Jäger differential method of this experiment, is due solely to the fact that narrow capillary tubes were employed. Preliminary experiments, which the author has already made on wider tubes (up to 5 mm. diam.), and for which the influence of the disputed term is about 3 per cent., have shown satisfactory confirmation of his own theory. He points out also that with the wider tubes one can easily observe the flattening of the bubble on its lowermost part, which theory requires, and also that the tangent plane to the bubble at the end of the tube at the moment of rupture is inclined to the vertical. Ferguson takes this tangent plane to be vertical. L. L.

1189. *Cubic Crystals formed of Theoretical Atoms.* **A. C. Crehore.** (Phil. Mag. 29. pp. 750–775, June, 1915.)—The author here continues the mathematical analysis of a former paper [Abs. 1779 (1913)], in which the integral of the general equation was obtained in one special case only, viz. when the axes of revolution of the two electrons are parallel, and the angular velocities of orbital revolution are equal. The work of integrating for average velocities is here completed in the most general case, when the two axes are inclined at any angle, and the frequencies of revolution are either equal or incommensurable. Much still remains to be completed in the mathematical analysis, but the author has succeeded in demonstrating the complete stability of a simple crystal of the cubic system, such as rock-salt or potassium chloride. He has also obtained dimensions for a crystal which agree within the limits of error with the experimental results of Bragg and others, and confirm his opinion that there is but a single atom at each corner of the cube in the crystals mentioned. G. W. DE T.

1190. *Thickness and Structure of the Capillary Layer.* **G. Bakker.** (Zeits. Phys. Chem. 86. pp. 129–176, 1914.)—The capillary layer separates liquid and vapour. Its thickness at low temperatures has, by an erroneous interpretation of researches by van der Waals (1878) and Kelvin (1888), been assumed to be, at low temperature, of the order of the diam. of a molecule. According to Laplace the thickness is of the order of the radius of the sphere of action of the molecular forces. If H is the surface tension and K the molecular pressure, then according to van der Waals, that radius would be $\zeta = 2H/K$, according to Kelvin $\zeta = H/K$ (lower limit). According to the author the thickness of the capillary layer (in the sense of Laplace) would be 14H/K; the forces of Boltzmann and van der Waals do not explain the phenomena. For water the thickness would be 1 or 2 millimicrons, $\mu\mu$, almost independent of the temperature; at 200° C. the value for water would still be 1·6 $\mu\mu$, by extrapolation. For ether the author finds by two methods, 2·6 or 2·1 $\mu\mu$ at 0°C. The paper deals essentially with the energy relations; the experimental data, taken from others, concern also nitrogen, argon, oxygen, carbon tetrachloride, benzene, etc., and other organic compounds. H. B.

1191. *Stability of some Liquid Films.* **P. Phillips.** (Phys. Soc., Proc. 27. pp. 328–338, June, 1915.)—The authors give a simple method of calculating the equilibrium form of a thin film which is a surface of revolution. They then consider the stability for certain kinds of displacement of three classes of such films, viz. the sphere, the cylinder, and the catenoid. The mathematics used is quite elementary throughout and the treatment is rigorous. AUTHOR.

1192. *Universal Significance of Planck's Element of Action.* **J. Ishiwara.** (Mathematico-Physical Soc., Tōkyō, Proc. 8. pp. 106–116, May, 1915.)—A general survey of the part played by this quantum in the various branches of physics. [See Abs. 785 (1912).] E. H. B.

1193. *On Slip-surfaces and Plasticity of Crystals.* **R. Schachenmeier.** (Ann. d. Physik, 46. 3. pp. 393–412, Feb. 12, 1915.)—Mathematical treatment.

1194. *Recent Work on the Structure of the Atom.* **W. D. Harkins** and **E. D. Wilson.** (Am. Chem. Soc., J. 37. pp. 1396–1421, June, 1915.)

*1195. *Report of the National Physical Laboratory for the Year* 1914–15. (Report [136 pp.] Teddington, 1915. Abstracts in Engineering, 99. pp. 707–709, June 25; 100. pp. 27–29, July 9; 64–65, July 16, and pp. 91–92, July 23, 1915. Electrician, 75. pp. 422–423, June 25, and pp. 463–466, July 2, 1915.)—The work of the various departments is briefly summarised in the usual manner [see Abs. 1474 (1914)]. L. H. W.

1196. *Ultramicroscopical Particles.* **F. Ehrenhaft.** (Phys. Zeits. 15. pp. 952–954, Dec. 15, 1914.)—A method for ascertaining the diameter of ultramicroscopic particles by observing the colour of the light selectively dispersed by them. A. D.

1197. *Structure of the Spinel Group of Crystals.* **W. H. Bragg.** (Nature, 95. p. 561, July 22, 1915. Phil. Mag. 30. pp. 305–315, Aug., 1915.)—The spinel group of crystals are cubic in structure and possess the greatest possible number of symmetries. The structure is fundamentally the same as that of the diamond. Each carbon atom of the diamond is to be replaced by the divalent metal atom, the distance between two neighbours being 3·60 Å.U. in magnetite, as compared with 1·53 Å.U. in diamond. The divalent atom lies at the centre of a tetrahedron of oxygen atoms, and the trivalent at the centre of an octahedron. A. B. W.

1198. *Fundamental Equations of Mechanics.* **T. L. Porter** and **R. C. Gowdy.** (Science, 41. pp. 825–827, June 4, 1915.)—Discussion of a proposal by Kent (Ibid. p. 424, March 19, 1915) to make V = FT*g*/W the fundamental equation of mechanics. The authors advocate a system under which force, distance, time, quantity of matter, acceleration (terrestrial gravitational), and velocity (that of light) are treated as independent fundamental conceptions and brought into accord by the use of proportionality constants. A. D.

1199. *Form of Ultramicroscopical Silver Particles.* **R. Gans.** (Ann. d. Physik, 47. 2. pp. 270–284, June 1, 1915.)—It is theoretically shown that the absorption curves of colloidal silver solutions (as with gold solutions) is a very delicate means of determining the form of the silver particles. The experimental curves then show (as previously with gold) that the silver particles have with close approximation the spherical form. The notion of Siedentopf and Zsigmondy, that the particles had the form of discs or leaves is in nowise supported. [See Abs. 1323 (1912).] E. H. B.

1200. *Density of Liquid Hydrogen. Refractivity and Dispersion of Liquid Hydrogen and Liquid Nitrogen.* **H. Augustin.** (Ann. d. Physik, 46. 3. pp. 419–445, Feb. 12, 1915. Extract of Dissertation, Leipsig.)—The density of liquid hydrogen by the float method has been found to be 0·07105 for a barometric pressure of 745·52 mm. and a temperature of —252·83° C., the error being not greater than 0·8–0·9 per thousand. The values of the coefficient of refraction, at —252·83° for hydrogen and at —195·88° for nitrogen, are :—

	λ = 656·3	579·0	546·1	435·9	404·7
Hydrogen......	1·10924	1·10974	1·11008	1·11179	1·11262
Nitrogen	1·19715	1·19746	1·19788	1·20010	1·20125

The experimental values are employed for the calculation of the Wiener number. A. F.

1201. *Theory of the Winds.* **R. M. Deeley.** (Phil. Mag. 29. pp. 13–33, July, 1915.)—Gives a general account of the winds of the globe and their association with surface pressure and temperature distribution. Temperatures in the upper levels of the atmosphere are also considered. The conclusion is reached that in the equatorial regions between 30° N. and 30° S. latitude it is the surface temperature conditions which exercise a predominant influence on the winds, while in higher latitudes the strong temperature gradient along the meridians in the stratosphere becomes the controlling feature. J. S. Di.

1202. *Relation between Monthly Values of Atmospheric Pressure-variation, and Simultaneous Monthly Values of Temperature-variation and Humidity, and Geographical Latitude.* **N. Ekholm.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 3. pp. 1–11, 1914.)—Köppen has considered the relation between pressure variation and the latitude of the observing station, the "deflecting force of the earth's rotation," and the friction between air and earth, but as the energy of all atmospheric motions can ultimately be expressed in terms of temperature and humidity, the author endeavours to discover a relation between pressure variation on the one hand, and temperature variation, humidity, and latitude of observing station on the other. Hann had already found that temperature variations alone cannot account for the observed pressure variations.

The investigation refers to the three winter months Dec. to Feb. only, and the data used are monthly values from 28 stations between lats. 50° N. and 70° N. If L is mean monthly pressure variation, W the simultaneous temperature variation, and F the simultaneous mean vapour-pressure for a station of which the latitude is ϕ, it is found that the equation

$$L = 8{\cdot}73 \sin^2 \phi \,.\, F + 1{\cdot}07 \sin^2 \phi \,.\, W$$

expresses with considerable accuracy the dependence of L upon ϕ, F and W. The equation applies both to continental stations, where F is small and W is large, and to maritime stations, where F is large and W is small. Thus the values of the two terms on the right-hand side of the equation for the two stations Jakutsk (Siberia) and Valencia (S.W. Ireland) are respectively 0·88, 28·01 and 34·86, 8·69. The computed values of L are therefore 28·9 and 43·5, which differ from the actual values by 1·4 and 2·1. R. C.

1203. *Condensation upon and Evaporation from a Snow Surface.* **B. Rolf.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 9. 35. pp. 1–19, 1914.)—The following experiments were carried out in Swedish Lapland. Four shallow zinc trays, each about 600 sq. cm. in area and 3 cm. in depth, containing snow, were exposed in the open upon the snow-covered ground in such a way that their rims were level with the general surface of the snow. The trays were carefully filled with snow before each experiment and weighed. They were again weighed after an exposure of 24 hours in winter, or 12, 6, 3, or even 2 hours in summer. The difference in weight gives the gain or loss by condensation or evaporation. The experiments were carried out uninterruptedly from Dec. 1905 to July 1906, but most of the results could not be used, being vitiated by disturbing causes. Of these, drifting snow was the principal in winter, and absorption by the trays of solar radiation was common in summer, producing an excess of melting and evaporation. The results of the experiments which were finally accepted as trustworthy are printed in full. In winter, and up to the beginning of June, the ground was completely covered with snow, but afterwards numerous bare patches were rapidly developed, and by the middle of July the snow had disappeared. Before June, water-vapour therefore passed between the air and a snow surface; afterwards humid soil enters also into the process.

It is found that when snow covers the ground the condensation (C) can be connected with the duration of exposure in hours (t), the max. vapour-pressure at the temperature of the snow layer (f), and the actual vapour-pressure of the surrounding air (F) by the formula $C = at + b(F - f)t$, where a and b are constants, which are determined from the observations by the method of least squares. A negative value of C indicates an evaporation instead of a condensation. In winter a is practically zero, and the formula is—

$$C = + 0{\cdot}0174(F - f)t.$$

In spring, when the air temperature is above 0° C., and snow still covers the ground, f is the saturation vapour-pressure at 0° C., and is therefore constant (4·6 mm. of mercury). The formula becomes—

$$C = - 0{\cdot}0010\,t + 0{\cdot}0168(F - 4{\cdot}6)t.$$

The cases when the ground is only partially covered could not be expressed by a similar formula, but it was found that by grouping the experiments according to time of day, values of a and b could be computed for each group, and these values showed a marked diurnal variation. Thus in the morning a was $+ 0{\cdot}009$; it reached a maximum $+ 0{\cdot}020$ in the afternoon, and fell off again in the evening and night. The constant b also showed a maximum during the day hours of about $+ 0{\cdot}029$ and a minimum during the night of $+ 0{\cdot}016$. The errors resulting from the use of these formulæ are small in comparison with the amount of condensation or evaporation. R. C.

1204. *The Distribution of the Rainfall of the United States.* **B. C. Wallis.** (Monthly Weather Rev. 43. pp. 11–24, Jan., and pp. 170–175, April, 1915.)—The first article deals with the North-Eastern States and the second with the Western States. The original articles should be referred to for the numerous maps showing the equipluves. L. H. W.

1205. *Approximate Calculation of Climatic Influence on Speed of Subterranean Temperature-increase with Depth.* **J. Boussinesq.** (Comptes Rendus, 160. pp. 747–750, June 14, 1915.)—This paper [see also Abs. 984 (1915)] contains a mathematical discussion of climatic influence on subterranean temperatures. On the hypothesis, generally accepted, of a thin terrestrial crust resting on a fused or pasty core from which the crust has been formed by rapid solidification, the permanent inequality of solar action, or climatic variation due to this inequality is found to have only slight influence upon the rapidity of temperature-increase with depth. H. H. Ho.

1206. *On the Extreme Slow Rate of Cooling at Great Depths, and the use of this for Investigating the Solidification of the Earth's Crust from a given Epoch.* **J. Boussinesq.** (Comptes Rendus, 160. pp. 787–798, June 21, 1915.)—The paper is a continuation of previous communications [see preceding Abs.], and first deals with the approximate evaluation of the integral—

$$\psi(\omega) = \int_{\omega}^{\infty} e^{-a^2}\,da$$

to investigate the form of the asymptotic expression for cooling when ω increases. The author then discusses the various conditions which arise, and which determine the progress of solidification. H. H. Ho.

1207. *Avezzano Earthquake.* **G. Agamennone.** (Accad. Lincei, Atti, 24. pp. 240–246, Feb. 25, 1915.)—The most probable location of the epicentre is the Fucino basin, somewhere on the southern slope of Monte Velino. But it is possible that there were two distinct epicentres, the second earthquake being a "relay" started by the first. The Montecassino record gives the start at 7h. 52m. 50s., that of Rocca di Papa is 4 secs. later, and that of Rome Observatory 5 secs. later. At Trieste (400 km. from Avezzano) the time of commencement was 7h. 53m. 39s., and at Hamburg (1300 km.) 7h. 55m. 33s. This gives a surface velocity of 7700 metres per sec., and the probable time of start at the true epicentre is 7h. 52m. 44s. At Rocca di Papa the amplitude was too great to be registered until 8h. 37m. Between that time and midnight no less than 240 shocks were recorded. E. E. F.

1208. *How Volcanism might be Explained.* **C. G. S. Sandberg.** (K. Akad. Amsterdam, Proc. 18. pp. 10–16, July 13, 1915.)—The present paper commences with a review of the principal attempts to explain volcanic eruptions and the mode of their origin. It has long been considered necessary to assume that large quantities of sea water were suddenly brought in contact with incandescent and liquid magma, by means of deep-reaching fissures or crevasses, in the earth's crust, and a causal connection between these phenomena seemed very probable in view of the similarity in many respects between gaseous volcanic emanations and the constituent elements of sea water, as also with the proximity of the seat of volcanic activity to marine areas. This theory is now acknowledged untenable, since some volcanic areas are remote from the sea, while it is admittedly impossible for sea water to penetrate to the magma along one fissure and be violently expelled again along another and more difficult passage. Daubrée tried experimentally to establish the possibility of the necessary explosive energy being furnished by the contact of water reaching magma by capillary attraction through the sedimentary strata, but his assumption proved untenable. Lately A. Brun has denied the existence of water-vapour in large quantities in volcanic emanations, an assertion refuted by Day and Shepherd. From the distribution of volcanic regions the present author notes that in general they coincide with the faulted and fissured regions of the globe, and opines a causal connection to exist between them. He then discusses sedimentation under sea water, and to arrive at an appreciation of the quantity of sea water which could possibly be contained in sedimentary strata he examines the extent of its pore-space, and arrives at the conclusion that the amounts are practically the same whether the deposits are relatively near the surface or at great depths, and vary between the values of 16 to 70 per cent. by volume. The question next considered is whether it may be taken as probable that the water originally occluded in these sedimentary deposits will not have been expelled from there (by the tension of the vapour-converted water of underlying strata), long before these sediments could have reached the zone of liquefaction. For should the water (vapour) still fill the pore-spaces, a sufficiently sound basis for explaining the origin and mechanism of volcanism were to be found, in the quantity of occluded water (vapour) and the high tensions acquired by it under the influence of excessive high temperatures reigning in the magmatic zone. The mechanism of volcanism might then be considered as follows: When by the action of isostatic influences, a fissure or fault be engendered, the vapour tensions existing in the vicinity of such faults or fissures would discharge themselves entirely or partly in such fissure or fault. Part of the plastic (or liquid) rock would be carried along, as water overcharged with

CO_2 is carried along, by sudden and sufficient relief of pressure. The subsidence of sedimentary deposits ever continuing, through accumulation of products of erosion, water (vapour-) charged sediments would ever and anon be conducted into the regions of excessively high temperatures, which might account for the periodicity of volcanism. Finally the question is considered as to whether it is plausible that the sea water imprisoned in the pore-spaces of sedimentary strata may be there still when these sediments have reached depths where liquefying temperatures are reigning. The frictional resistance of liquids in the enormous capillary channels is held to be more than sufficient to counteract the expulsion effect of vapour tension due to high temperatures.
H. H. Ho.

1209. *Viscosity of the Earth.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 75. pp. 648–658, June, 1915.)—Estimates of the interior viscosity of the earth may be obtained either by attributing the empirical part of the secular acceleration of the moon's mean motion to bodily tidal friction, or by direct experimental investigation similar to that of Michelson, who employed a special type of water pendulum to measure the lag of the lunar tides. An analysis is given to investigate the effect of an assumed viscosity on the phenomenon of variation of latitude. This indicates that the vibration should die down within a few days, whereas in actual fact we know that the variation of latitude has existed without any great change in amplitude for many years. Several possible explanations of the disagreement are considered, but with no definite result, and further experimental evidence is suggested as advisable. C. P. B.

1210. *Irregular Motion of Earth's Axis of Rotation.* **J. Larmor** and **E. H. Hills.** (Roy. Astron. Soc., M.N. 75. pp. 518–521, May, 1915.)—In a previous paper [Abs. 418 (1915)] the authors determined the graph of the minute wanderings of the earth's axis of rotation, from the published data by the International Polar Commission. They now continue the analysis of the possible causes of the movements, chiefly in the direction of considering the influence of the disturbing torques which may be produced by changes of position of loose material on the earth's surface. A diagram showing this effect for the period 1905–1910 is appended. C. P. B.

1211. *Vatican Magnitudes in Astrographic Catalogue.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 75. pp. 601–609, June, 1915.)—The paper is in continuation of others dealing with the comparison of the magnitude scales of the Astrographic Catalogue [see Abs. 822 (1915)], and utilises the photographs taken at the Vatican Observatory for determining the distribution of certain areas in the sky where there appears to be evidence of some system of obscuration. Additional evidence is given for supposing that the phenomenon has no relation to the Milky Way. C. P. B.

1212. *Gravitational Displacement of Spectral Lines in Fixed Stars.* **E. Freundlich.** (Phys. Zeits. 16. pp. 115–117, April 1, 1915.)—The author has previously pointed out that on Einstein and Nordström's gravitational theory the sun's lines are redwardly displaced, and a recent series of observations by Schwarzchild tends to confirm his general conclusions. The author now communicates a statistical consideration of the problem which supports the view that gravitational displacements of the spectral lines occur in a fixed star-system, in spite of the fact that the enormous movements relative to the earth would apparently produce Doppler-effects which mask all other displacements. Campbell's statistical investigations are quoted on the velocities of stars possessing different spectral characters, these showing systematic displacements varying with the spectral class of the fixed stars. These data are employed by the author for estimating the masses and densities of stars in the various star classes, on the assumption that the spectral lines are gravitationally displaced. He believes that with more data on the spectra of double stars, where both spectra are visible, a direct method could be evolved for testing and establishing his conclusions. H. H. Ho.

1213. *Some Problems Illustrating the Forms of Nebulæ.* **G. W. Walker.** (Roy. Soc., Proc. 91. pp. 410-420, July 1, 1915.)—The possible forms of distribution of a mass of gaseous material under the influence of its own gravitation are of considerable interest in the nebular theory. The law of density which it appears most reasonable to assume is Boyle's Law, in which the pressure is proportional to the density, unless the pressure becomes so great that the material begins to resemble an incompressible substance. Although it is unlikely that the temperature is uniform throughout, still under this restriction the solution is of value as a step in the direction of greater knowledge as regards possibilities in astronomical phenomena. The equations when formed lead to a differential equation for the surfaces of equal density which is not linear. In the three-dimensional case little progress to a general solution has been made, but in the two-dimensional case considerable progress has been made. The author had previously obtained the exact solution of the statical case of symmetry about the origin, but then found that Pockels had already produced the complete solution of the statical two-dimensional equation. No further application of Pockels' solution having been made, the present author has examined some particular cases, given in this paper, and arrived at results indicating such a close analogy with actual astronomical forms that he hopes they may be of interest as suggesting types which may be expected in three dimensions. The important related problem of a rotating nebula is also considered, and the conclusion drawn that the effect of the rotation, when very slow, is to diminish the density near the origin and to increase it at greater distances, but that there is no clear tendency to throw off the outer layers. From the cases considered it would appear that a finite boundary of a gaseous mass is not to be looked for as a consequence of rigid-body rotation, but rather as a consequence of some other type of motion in which viscosity may play a part. H. H. Ho.

1214. *Form of Rotating Liquid Mass disturbed by Satellite.* **H. Glauert.** (Roy. Astron. Soc., M.N. 75. pp. 629-648, June, 1915.)—An analytical investigation is developed for determining the form assumed by a rotating fluid mass under the influence of a satellite which describes a circular orbit in the equatorial plane of the primary, taking into consideration any possible relative movement of the fluid, and that the bodies may be of different densities.

C. P. B.

1215. *Tilt of Plate in Stellar Photography.* **R. J. Pocock.** (Roy. Astron. Soc., M.N. 75. pp. 661-665, June, 1915.)—If the photographic plate in an astronomical camera is not square into the optical axis of the lens, then if a plate be exposed on a field of stars of approximately uniform distribution in numbers, it will be found that the number of stars recorded will vary in different parts of the plate, and the variation due to tilt may be computed and checked with the actual counts. The method is illustrated by examples of counts on plates taken at Oxford and Hyderabad. C. P. B.

1216. *Magnitude Scales of Astrographic Catalogue.* **R. J. Pocock.** (Roy. Astron. Soc., M.N. 75. pp. 659–660, June, 1915.)—Assuming that each zone is a fair sample of the whole sky, it is possible to utilise the photographic scale of magnitude published by Chapman and Melotte by simple counts of the numbers of stars of a given diameter, allowance being made for observer's personality. This has been done in the case of the Cape and Perth catalogues, and the results of the analysis are included. C. P. B.

1217. *Errors of Measurement.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 75. pp. 609–611, June, 1915.)—Referring to the paper by W. Gibson [Abs. 823 (1915)] in which, to acquire the highest accuracy, it was recommended that measurements be made in four orientations, the author states that the usual method of measuring in two orientations gives the accuracy desired, and discusses some of the figures to support his contention. C. P. B.

1218. *Solar Rotation in June,* 1911. **J. B. Hubrecht.** (Roy. Astron. Soc., M.N. 75. pp. 611–625, June, 1915.)—In a former paper the results were given of measures of plates taken in 1910 and 1911, one set concerning the solar rotation at the equator only, the other giving comparisons of radial velocities at points all round the sun. [Abs. 572 (1913).]

In June, 1911, four series of plates were obtained, and the present paper gives the results of measures of these by another observer. By comparison of results from different lines in the spectrum it appears that the velocity-differences observed vary regularly from one end of the spectral region to the other. The velocities appear to be arranged symmetrically with respect to the solar axis, but not with respect to the equator, the sum of the velocities in the Northern Hemisphere being greater than the corresponding sum in the Southern Hemisphere. C. P. B.

1219. *Large Eruptive Prominence,* 1915 *April* 19. **C. P. Butler.** (Roy. Astron. Soc., M.N. 75. pp. 553–555, May, 1915.)—Illustrations are given showing details of a large eruptive prominence photographed with the spectroheliograph of the Cambridge Observatory on 1915 April 19, at 10.40 a.m. The prominence was in the form of an arch, whose sides were some 38° apart on the eastern limb of the sun; the highest portion of the arch reached to about 480 seconds of arc, one-fourth of the solar diameter. Unfavourable weather prevented further photographs until 11.40 a.m., when only the basal portions of the prominence were present. C. P. B.

1220. *Anomalous Dispersion in Sun.* **S. Albrecht.** (Astrophys. J. 41. pp. 333–358, June, 1915.)—Comparisons are made between the wave-lengths of iron lines in laboratory and solar spectra in order to determine whether the wave-lengths of lines having close companions towards the red or towards the violet in the solar spectrum differ systematically from each other and from the lines which are not thus accompanied by close companions. The discussion of the evidence shows that the Fraunhofer lines, as given by Rowland, are displaced when they have close companions, the displacement being towards the violet if the companion is towards the red, and towards the red if companion is towards the violet. The displacement in the first case is greater than in the second, thus being in agreement with the requirements of anomalous dispersion. C. P. B.

1221. *Displacements of Enhanced Lines at Centre of Sun's Disc.* **J. Evershed and G. Nagaraja.** (Kodaikanal Observat., Bull. 46. Nature, 95.

p. 519, July 8, 1915. Abstract.)—General displacements of solar lines towards the red have been interpreted as due to movements of solar gases in line of sight and not due to pressure, the effect indicating the fall of matter towards the solar surface from the higher atmosphere. This would imply a corresponding rise elsewhere of the hotter surface gases, and the authors have made a special study of the enhanced lines of iron in the sun and the electric arc. Results are given showing shifts for 16 lines, all except one being positive, showing that they cannot represent ascending gases. No evidence was found of any relative shift between enhanced and ordinary iron lines. C. P. B.

1222. *Diffusion of Radiations in Solar Atmosphere.* **V. Carlheim-Gyllensköld.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 12. pp. 1–29, 1914.)—A long analysis is made of the conditions regulating the variations of radiation at various parts of the sun's disc, for the determination of the law of absorption in the solar atmosphere. Tables are given showing the coefficients of absorption for various wave-lengths, and the results are discussed from the points of view of the influence of molecular diffraction or absorption by small particles in an agitated medium. C. P. B.

1223. *Elements of Moon's Orbit.* **E. W. Brown.** (Roy. Astron. Soc., M.N. 75. pp. 508–516, May, 1915.)—A summary is given of the newly established values of the moon's orbital elements determined from a comparison of the Greenwich meridian observations with the author's theory of the moon's motion. In most cases the results are found to be more accurate than those obtained from occultations. C. P. B.

1224. *Rotation Period of Neptune.* **M. Hall.** (Roy. Astron. Soc., M.N. 75. pp. 626–628, June, 1915.)—Observations made in Nov., 1888, suggested that there was considerable variation in the light of Neptune. The observations were continued on 1915 Feb. 26, and the variation again detected, similar irregularities being noted up to March 30. From May 8 to 10 no variation was detected. Taking the variations to indicate rotation, the period is given as 7h. 50m. 6s. C. P. B.

1225. *Origin of Comets.* **E. Stromgren.** (Publikationer og mindre Meddelelser fra Kobenhavens Observatorium, No. 19. Nature, 95. p. 493, July 1, 1915. Abstract.)—By means of backward computation of planetary perturbations for eight comets, evidence is furnished for the view that all the comets of the solar system have orbits other than hyperbolic, thus indicating that they originated in the system and have not been captured from beyond. C. P. B.

1226. *Spectrum Associated with Carbon and Wolf-Rayet Stars.* **T. R. Merton.** (Roy. Soc., Proc. 91. pp. 498–503, Aug. 2, 1915.)—Campbell has shown that the spectra of Wolf-Rayet stars show, in addition to lines of hydrogen and helium, a number of lines not yet identified in laboratory spectra. Owing to their great diffuseness it was not possible to determine their wave-lengths with great accuracy, so that efforts to determine a laboratory origin must depend on the coincidence of a number of the constituent lines. The author has obtained a spectrum, associated with carbon, of which the principal lines coincide with the most conspicuous lines of the Wolf-Rayet spectrum. The spectrum was produced by passing heavy condensed discharges through vacuum tubes containing hydrogen at moderately low pressure, provided with graphite or carbon electrodes. When freshly prepared the tubes showed only the spectrum of hydrogen with a trace of the Ångström carbon-oxide bands, but after running some time the hydrogen disappeared, leaving a brilliant spectrum of the Ångström bands. At the same time carbon was deposited in the capillary. With a condensed discharge and spark-gap the line spectrum of carbon appeared, and in particular a characteristic group of lines in the green, consisting of diffuse lines. These are compared with the Wolf-Rayet lines and show a suggestive agreement. A plate is given showing the spectra under five conditions of discharge. C. P. B.

1227. *Spectral Distribution of Stars of Large Radial Velocity.* **C. D. Perrine.** (Astrophys. J. 41. pp. 401–408, June, 1915.)—In the classification of stellar spectra it is noticed that the stars of largest radial velocities appear to be in Classes F, G, K. Tables showing data for 1800 stars show this very clearly, and it is also noted that stars of classes F and G have the largest average proper motions and are the nearest to the solar system. This tends to confirm the conclusion that the radial velocities, and probably the total velocities, are functions in general of the brightness, and possibly also of the sizes and masses of the stars. C. P. B.

1228. *Stellar Parallaxes.* (Roy. Astron. Soc., M.N. 75. pp. 592–600, June, 1915. From Royal Observatory, Greenwich.)—Experimental photographs for the determination of stellar parallax were taken with the 26-in. refractor at Greenwich in 1911, but the work was delayed owing to slight displacements of the components of the objective. After alteration the programme was resumed in Jan. 1913. At the same time an occulting shutter was fitted so that the magnitude of the star under observation could be equalised with the comparison stars. For a working list it was decided to use the stars of proper motion exceeding 20″ a century between Dec. + 64° and the North Pole, and a further 55 stars of large proper motion have since been added. The work is being done in co-operation with a committee of the American Astronomical Society to avoid duplication, apart from the desirable overlap for comparison. Kapteyn's method of making exposures at different epochs on the same plate has been adopted. To avoid hour-angle error all the exposures have been made within one hour of the meridian. Eight comparison stars have been used, selected to be near the same magnitude as the reduced parallax star (generally about 11·0 mag.), and in such positions that their mean is near that of the star being examined.

The results of determinations for 40 stars are given, with comparisons for the results by other observers for stars in common. The parallaxes are in the mean somewhat less than anticipated by theory. Tables are also given showing the relation of parallax to spectral type. C. P. B.

1229. *Variable Stars in Cassiopeia and Leo Minor.* **R. J. McDiarmid.** (Am. Phil. Soc., Proc. 58. pp. 66–69, Jan.–April, 1915.)—Four Algol variables, TV, TW, TX Casseiopeiæ and T Leonis Minoris, have been under observation for three years with the polarising photometer and 23-in. equatorial of the Princeton Observatory. Light-curves have been determined from the observations, and the periods obtained, the results being discussed in relation to their possible orbits as eclipsing variables. C. P. B.

1230. *Eclipsing Variable Stars.* **R. S. Dugan.** (Am. Phil. Soc., Proc. 58. pp. 52–57, Jan.–April, 1915.)—A series of notes are given of the results of photometric observations of the eclipsing variable stars RT Persei, *z* Draconis, RV Ophiuchi, including some comparisons with photographic determinations made at Harvard, which appear to furnish material for distinguishing preponderance of colour in the components of the variable system. C. P. B.

1231. *Maxima of S Herculis.* **T. E. R. Phillips.** (Roy. Astron. Soc., M.N. 75. pp. 557–566, May, 1915.)—Special interest attaches to this variable, as apart from its light-curve, the dates of maxima are extremely irregular. With the exception of an interval of 9 years, we have now observations extending from 1857 to the present time. In the present paper the whole of the available observations of maxima are discussed, from which it appears that irregularities sometimes amounting to 20 days are included. The observations consist of three series, (1) those made by Baxendell, (2) those made at Rousdon, (3) those made by members of the British Astronomical Association, and there appears to be a certain amount of discrepancy for the periods where comparison is possible. The discussion furnishes evidence of the existence of a periodic inequality, which is more complicated than a simple sine-term variation. C. P. B.

1232. *Statistics of Spectroscopic Binary Stars.* **S. Wicksell.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 6. pp. 1–15, 1914.)—A discussion is given of 440 spectroscopic binaries abstracted from Campbell's second list of 1910, and frequency curves of the periods are plotted for types B, A, F, G, K, with the exception of the Cepheids. From these curves is indicated the existence of two types of period. Comparison is made with the results obtained by Shapley for eclipsing binaries, showing that the densities of systems of F and G type fall into two groups, the long-period stars apparently forming the group of low density. C. P. B.

1233. *Short-period Variable R.R. Lyræ.* **C. Martin** and **H. C. Plummer.** (Roy. Astron. Soc., M.N. 75. pp. 566–572, May, 1915.)—This star is a variable of the cluster type discovered by Mrs. Fleming in 1901. The material for the present discussion consists of 108 photographs taken with the 15-in. reflector at Dunsink, between 1913 Oct. and 1914 Nov. The magnitudes of the comparison stars have been based on two plates exposed under similar conditions on the region of the variable and on the χ Persei cluster, the magnitude scale of the latter having been determined by Schwarzschild. The resulting observations of the light-variations are given tabularly and plotted in relation to the curves of radial velocity, visual magnitude, etc. C. P. B.

1234. *Relation between Stellar Radial Velocities and Magnitudes.* **C. D. Perrine.** (Astrophys. J. 41. pp. 395–399, June, 1915.)—Evidence has already been presented to show a relation between the radial velocities of 225 of the brighter stars of Class B and their magnitudes [Abs. 1012 (1915)], wherein it was found that the fainter stars have the greater velocities. The investigation is now extended to cover the stars of classes A, F, G, K and M recorded in Campbell's list of velocities, and it is found that the more complete survey confirms the preliminary result. Of 1309 stars examined, the highest velocities are found only among the fainter stars, without a single instance to the contrary. Of 33 stars having velocities of 50 km. per sec. and over, only one is as bright as mag. 2·4, and four are between 3·0 and 4·0. The magnitude-velocity equation appears to increase in the stars of later type. The greatest

velocities among the fainter stars of classes F, G, K appear to be on the borders of the Milky Way rather than near its central line, while in general the highest-velocity stars show a decided preference for the Milky Way.
C. P. B.

1235. *Great Aurora of* 1915 *June* 16. **E. E. Barnard.** (Nature, 95. pp. 586–587, July 15, 1915.)—A very remarkable exhibition of auroral activity was observed at the Yerkes Observatory on the night of 1915 June 16. Starting in the form of a strong low-lying arch without streamers, the activity gradually increased until the brilliant glow reached the pole, the lower portions being broken with bright moving masses, and the upper part being double. After dying down, the phenomenon was repeated some hours later, and then the arch structure gave place to long ascending streamers, quick waves of auroral light rising to the zenith with remarkable rapidity. These continued for over an hour until further observation was interrupted by dawn. The max. intensity occurred about 8.15 a.m. G.M.T. on the 17th of June. A few of the brightest masses could be detected 20 mins. after dawn. There was little colour in the display at any time, although a few of the streamers gave indications of a pink tinge. Photographs of the sky taken during the display were found to be badly fogged by the auroral light, which seemed to be more actinic than moonlight.

Widespread effects on telegraph systems appear to have occurred at the same time as the aurora. On the other hand wireless signals appear to have been normal throughout the period of the maximum display. C. P. B.

1236. *Aurora Observations in* 1913. **C. Störmer.** (Terrest. Magnetism, 20. pp. 1–12, March, 1915.)—Although only a part of the material obtained on the expedition to Bossekop in 1913 has been worked up, the author has now details of about 600 very exact measurements of the altitude of the aurora and of its position in space, all determined from photographs taken simultaneously from the two stations Bossekop, and Store Korsnes, lying about 27·5 km. from each other in a north and south line, and connected by telephone for direction of the observations. A notable result is the consistency with which the lower limit of altitude for the auroras is found to be from 90 to 100 km.

The pictures of the auroral draperies on March 11–12, 1913, have been examined for the purpose of determining the nature of the discharge. For this magnetograms for the same epoch were obtained from the observatory at Haldde, about 13 km. west of Bossekop. Marked perturbations were visible on the magnetograms, showing that the magnetic action was so directed that it had components pointing to the north, west, and upward. Assuming that the electric corpuscles descend into the atmosphere from without, along the magnetic lines of force, forming auroral rays, which combine to form the drapery, we can find by a simple application of Ampère's law that it seems to be proved that the aurora was caused by positively-charged electric particles. Diagrams are given in illustration of this view. C. P. B.

1237. *Meteor-falls in Earth's Atmosphere.* **S. Shinjo.** (Kyōto Coll. Sci., Mem. 1. 1. pp. 11–20, Oct., 1914.)—Estimates are made to get an idea of the mass of meteoric matter falling on the higher regions of the earth's atmosphere, with the intention of using the data in investigations of the physical nature of the upper strata. [See Abs. 1326 (1911).] C. P. B.

LIGHT.

1238. *Doppler-effect and Laws of Reflection and Refraction at a Moving Surface.* **A. Harnack.** (Ann. d. Physik, 46. 4. pp. 547–560, Feb. 26, 1915.)—A Doppler-effect may occur (i) when the source of light moves, (ii) when the observer moves, (iii) when light falls on a moving surface. The present paper gives a mathematical treatment of the third case. Applications of the results are made to a moving prism. A special case is considered where the three kinds of effect are combined, and the theory of the Michelson-Morley experiment is also discussed. A. W.

1239. *Phase-changes of Internally-totally-reflected Light at Doubly Refracting Crystals.* **S. Rybár.** (Ann. d. Physik, 46. 8. pp. 805–826, Feb. 12, 1915.)—A theory is worked out mathematically and compared with experiment, the agreement being fairly good though not exact. Four cases are considered, viz. the ordinary and extraordinary waves arising by reflection from ordinary and extraordinary incident waves. E. H. B.

1240. *Phase-changes of Reflected Light.* **S. Rybár.** (Ann. d. Physik, 46. 8. pp. 827–856, Feb. 12, 1915.)—Describes experiments which confirm the theoretical formulæ. E. H. B.

1241. *Dispersion of Light by Gaseous Bodies in the Ultra-violet.* **J. Koch.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 1. pp. 1–11, 1914.)—In previous papers [Abs. 282, 288 (1914)] the author has investigated the dispersion in the ultra-violet in dry air, nitrogen, hydrogen, helium, etc. The present paper gives the results obtained for CO$_2$ and CO. The same apparatus was used as in the earlier work, certain improvements having been made. A. W.

1242. *Focal Length of a Thick Mirror.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 18. pp. 115–126, June, 1915.)—The thick mirror consists of a piece of glass bounded by two spherical surfaces and silvered at the back, or of a more complicated arrangement consisting of any number of thin or thick lenses arranged along an axis, the reflection taking place at a plane or spherical silvered surface situated behind the last lens. The paper describes three experimental methods for obtaining the position and focal length of the equivalent ideal mirror, namely: (1) Gauss' method; (2) micrometer method; (3) goniometer method—so called because they correspond to the similar methods used for determining the focal lengths of thick lenses. T. H.

1243. *Astigmatism of Nicol Prisms.* **S. Becher.** (Ann. d. Physik, 47. 3. pp. 285–364, June 10, 1915.)—A description is first given of the phenomenon, with theory. Methods are then described whereby the effect can be compensated, special reference being made to the polarisation microscope. The paper contains numerous tables and diagrams, and does not admit of brief abstract. A. W.

1244. *Spectrographs.* **J. Wimmer.** (Phys. Zeits. 16. pp. 127–138, April 1, 1915.)—A paper dealing with the optical properties of the lens systems, etc., required for the best results to be given by spectrographs. [See Abs. 2861. (1904).] A. W.

1245. *Third-order Aberrations of a Symmetrical Optical Instrument.* **E. H. Smart.** (Phil. Mag. 30. pp. 270–282, Aug., 1915.)—Mathematical.

1246. *Variations in Luminous Intensity.* **A. Landé.** (Phys. Zeits. 15. pp. 946–952, Dec. 15, 1914.)—Mathematical discussion of the probable sums of variation. Conclusion that beyond a relatively small number, the variations in the illumination at a point are independent of the number of luminous point-centres. A. D.

1247. *Optical Dispersion in Moving Bodies.* **J. Laub.** (Ann. d. Physik, 46. 5. pp. 705–719, March 16, 1915.)—A derivation of the fundamental equations of the dispersion theory for moving bodies from the point of view of the relativity principle. [See Abs. 1062 (1909).] E. H. B.

1248. *Colouring of Light by Metallic Particles.* **R. Schachenmeier** (Ann. d. Physik, 46. 7. pp. 1009–1012, April 20, 1915.)—A mathematical treatment of the subject based on the author's previous work, in which the diffraction of light at screens is developed. E. H. B.

1249. *Electron Optics of the Hydrogen Molecule.* **A. Heydweiller.** (Deutsch. Phys. Gesell., Verh. 17. 9. pp. 179–188, May 15, 1915.)—A theory based upon known experimental data and culminating in calculated values for the frequencies and optical rotativity which are of the right order. [See Abs. 1752 (1913).] E. H. B.

1250. *Optical Paradox.* **A. Landé.** (Phys. Zeits. 16. pp. 201–204, June 1, 1915.)—A mathematical treatment of a so-called paradox in the Fourier analysis of composite light. E. H. B.

1251. *Lippmann's Colour Photography.* **K. Försterling.** (Phys. Zeits. 15. pp. 940–942, Dec. 15, 1914.)—A mathematical research, assuming that the plate is made up of numerous lamellæ. A. D.

1252. *Magnetic Rotation of the Plane of Polarisation in Titanium Tetrachloride.* **L. H. Siertsema.** (K. Akad. Amsterdam, Proc. 18. pp. 101–106, July 18, 1915.)—Titanium tetrachloride is the only known diamagnetic substance that exhibits negative magnetic rotation and is free from absorption bands over almost the whole of the visible spectrum. Further, since it is a liquid, its magnetic rotation may be observed without the interfering influence of a solvent. From the results of Becquerel's measurements (1877), it appears that the magnetic rotations are inversely proportional to the fourth power of the wave-length, this law being entirely different from that followed in the case of positive magnetic rotations. The results of the author's measurements for various wave-lengths and different temperatures show that the temperature coefficient is so small that it cannot be determined with accuracy. The numerical results are to be discussed in a later paper. T. H. P.

1253. *Electric Double Refraction.* **N. Lyon.** (Ann. d. Physik, 46. 6. pp. 753–784, March 30, 1915. Dissertation, Freiburg.)—When plane-polarised light passes through a length l of a liquid contained between two parallel plates distant a apart and at 45° with the plane of polarisation, the retardation δ (in terms of λ) between the two emergent rays on application of a p.d. P between the plates is given by $\delta = Bl(P/a)^2$, where B denotes the Kerr electric constant for the liquid. The author points out the lack of agreement between the values of B obtained by different observers. Measurements made by the author with different samples of CS_2, using the same apparatus, and avoiding dust contamination, have convinced him that the degree of purity, so long as the liquid preserves its insulating properties, has little effect on the absolute value of the constant. He considers that the discrepancy arises in the measurement of the electric field intensity, the edge effects of the condenser plates having been neglected by some observers. The author has determined the absolute value of B for CS_2, using a compensating quartz wedge and half-shade polarimeter. The measurements were carried out over a range 460·2 μμ–670·8 μμ. The table gives the results observed and also the value of the Kerr constant calculated from the mean value of the Havelock dispersion constant $C = B\lambda n_0/(n_0^2 - 1)^2$, where n_0 is the refractive index of the liquid for light of wave-length λ. The values of the refractive index were taken from Landolt and Börnstein's tables.

CARBON BISULPHIDE 20°. MEAN $C = 1{\cdot}184 \times 10^{-11}$.

Wave-length, μμ..	460·2	497·2	508·6	527	546·1	560·8	579	589	610·4	670·8
$B \times 10^7$ observed	4·69	4·10	3·95	3·76	3·55	3·44	3·31	3·21	3·05	2·79
$B \times 10^7$ calc.	4·60	4·09	3·95	3·75	3·57	3·44	3·31	3·23	3;07	2·78

The constant was then determined for other liquids over a similar range by aid of a compensation method. In this the plane-polarised ray traverses successively a parallel-plate condenser containing the liquid (l_1, a_1), and one containing CS_2 (l_0, a_0). The plates of the former are fixed at 45° to the plane of polarisation of the ray, while those of the CS_2 condenser can be rotated about an axis parallel to the plane of polarisation. The dimensions of the CS_2 condenser are such that when its plates make 45° with the plane of polarisation the path difference introduced is greater than that due to the liquid condenser. The p.d. between the plates of each condenser being the same, compensation is attained by rotating the plates of the CS_2 condenser through an angle a. In this case $B_1 = B_0(l_0 a_1^2)/l_1 a_0^2)f(a)$, where B_1 is the Kerr constant for the liquid and B_0 that for CS_2. $f(a)$ is determined by using CS_2 in the fixed condenser and varying the p.d. between the plates of one condenser.

The results are given in the following table :—

Wave-length, μμ.	Chloroform 20° $C = -2{\cdot}100 \times 10^{-11}$		Ethylether 20° $C = -0{\cdot}673 \times 10^{-11}$		Cumene 20° $C = 1{\cdot}287 \times 10^{-11}$		α Bromnaphthalene 20° $C = 3{\cdot}333 \times 10^{-11}$		Nitrobenzene 20° $C = 194 \times 10^{-11}$	
	$-B \times 10^7$ obs.	$-B \times 10^7$ calc.	$-B \times 10^7$ obs.	$-B \times 10^7$ calc.	$B \times 10^7$ obs.	$B \times 10^7$ calc.	$B \times 10^7$ obs.	$B \times 10^7$ calc.	$B \times 10^7$ obs.	$B \times 10^7$ calc.
470	3·79	3·81	0·695	0·755	—	—	—	—	—	—
500	3·48	3·53	0·668	0·704	2·74	2·71	13·18	13 09	503	500
527	3·29	3·34	0·642	0·669	2·54	2·54	12·17	12·14	466	466
560	3·06	3·11	0·620	0·619	2·38	2·36	11·11	11·15	427	428
586	2·95	2·95	0·606	0·587	2·24	2·24	10·50	10·53	401	403
617	2·85	2·79	0·584	0·555	2·09	2·11	9·75	9·78	376	378
645	2·78	2·66	0·576	0·530	2·03	2·01	9·36	9·32	357	358

L. L.

1254. *Tube-arc Spectrum of Iron.* **A. S. King.** (Astrophys. J. 41. pp. 373–394, June, 1915.)—The phenomena of the tube-arc have been previously described [Abs. 1655 (1913)]. One of the chief features is the dissymmetry produced in certain lines, and these have been specially studied in relation to the spectra produced by a much larger transformer which has recently been installed at the Pasadena Laboratory, the exposures being made while the current fell from about 1000 to about 600 amps. The spectra were taken in the second order of a grating spectrograph of 30 ft. focal length, having a linear scale of 1 mm. = 0·9 Å. Quite definite results were obtained, showing that in the tube-arc, as in the disruptive spark, many spectrum lines have an unsymmetrical structure, and observations with a microphotometer indicate that this is caused by the region of strongest excitation giving a displaced line, usually towards the red. Much variability appears in the amount of the dissymmetry for different lines, its magnitude evidently being related to the furnace classification of the lines and to their displacements under pressure. Lines of large dissymmetry are faint in furnace relatively to arc, and are greatly displaced by pressure. The degree of the effect has relation to the width of the line, strong lines being more displaced than weak ones. The results show that, in general, a condition of strong electrical excitation, combined with higher vapour-density, produce a displacing action strongly resembling that due to pressure. C. P. B.

1255. *Enhanced Series of Lines in Spectra of the Alkaline Earths.* **W. M. Hicks.** (Roy. Soc., Proc. 91. pp. 451–468, July 1, 1915.)—The problem of the limits and numerical relations between the lines of the enhanced series of doublets in the alkaline earths has for long been a difficulty to spectroscopists. W. Ritz [Abs. 1619 (1908)] gave arrangements for the sharp series from Mg to Ra inclusive, and proposed series formulæ for Ca, Sr, Ba, in which alone he had three lines from which to calculate the constants. The values of these constants were quite out of line with those of the analogous constants in other series, and produced a doubt as to whether it gave the right relation. It is now possible to test his limits by considering whether the denominator differences which give the observed separations have any relation to the "oun" or not. The result of this consideration is definitely adverse. In none of the three is it possible to make the differences multiples of the oun without supposing observation errors in the doublet separations which are quite inadmissible; and even then in the cases of Ca and Ba by taking odd multiples of δ_1, which is never the case for S-doublets in any other known series. There can be little doubt that A. Fowler [Abs. 1680 (1914)] has settled this question by taking the Rydberg numerator constant to be 4N in place of N, thus combining in one set lines which on the old supposition would be arranged in two series, depending on sharp and principal sequences.

The object of the present paper is the determination of the connection of these series with certain laws which have been arrived at in previous papers [Abs. 1364 (1912); 1958 (1913)], and more especially their dependence on the quantity called the "oun." Fowler's formulæ are utilised for Ca, Sr and Mg, and a discussion is added for the corresponding lines in Ba and Ra. A. W.

1256. *Origin of Certain Spectrum Lines.* **T. R. Merton.** (Roy. Soc., Proc. 91. pp. 421–431, July 1, 1915.)—A paper dealing with the application of interference methods to the study of the origin of certain spectrum lines. Much progress has been made in recent years in the study of the nature of spectra and of spectral series, but very little definite evidence as to the nature of the luminous particles from which different spectrum lines originate is as yet available. Buisson and Fabry's method of attacking the problem consists in measuring the limiting order of interference at which fringes can be observed for different radiations [see Abs. 1190 (1912)]. The limiting order of interference depends on the widths of the spectrum lines, from which certain deductions may be made with regard to the temperature of the source of the radiations, and the masses of the particles which are concerned in their production. The theory of the method has recently been discussed by Rayleigh [Abs. 555 (1915)] and by Schönrock. In the case of radiations produced at low pressures, the limiting order of interference (N) at which fringes may still be visible is given by the relation $N = K\sqrt{(M/T)}$, where K is a constant, M the atomic weight of the luminous particle, and T the absolute temperature. It is pointed out that any observed value of N can be confidently accepted as an inferior limit. If, therefore, the mass of the luminous particles is assumed, a superior limit of the temperature of the source may be calculated with certainty. In the experiments here described the values of N were determined by means of a Fabry and Perot sliding interferometer, used in conjunction with a large constant-deviation spectroscope, each spectrum line appearing as a narrow strip of a ring system. The value of the constant K agreed closely with Buisson and Fabry's value $1{\cdot}22 \times 10^6$, which value is adopted in the discussion of the results. Experiments were made with the *g*, H and K lines of calcium, some flame lines of strontium and barium, the two spectra of argon, and the band spectrum of helium. Some general deductions are made with reference to the characteristics of series lines. The results obtained with Ca are in accord with the supposition that the *g* line is due to Ca-molecules of mass 80, the H and K lines being due to Ca-atoms of mass 40, which would give a superior limit for the temperature of the vacuum arc of about 3000° C. It appears that for the lines λ4067 (Sr) and λ5585 (Ba) molecules are again concerned in the production of the radiations. The appearance of band spectra is usually associated with molecules, and thus the interpretation of the results obtained would require the recognition of the fact that molecules may give rise to line series as well as to band spectra. As regards the two spectra of argon the supposition that the luminous particles concerned in the production of the blue spectrum are smaller than those from which the red spectrum originates, would lead to so low a value for the mass in the former case that the supposition could hardly be accepted in the absence of further evidence. Some additional cause of broadening in the case of the blue spectrum may be operative, as Buisson and Fabry have supposed in the case of the Balmer series of hydrogen. It appears extremely probable that the band spectrum of helium is due to particles of atomic mass. A. W.

1257. *Band Spectrum associated with Helium.* **J. W. Nicholson.** (Roy. Soc., Proc. 91. pp. 432–439, July 1, 1915.)—Fowler has recently made a significant addition to our knowledge of the nature of band spectra [Abs. 557 (1915)]. In the case of the band spectrum found in connection with helium and hydrogen he has shown that the universal constant of Rydberg belongs to this spectrum, which contains two series of double "heads" arranged essentially in the same manner as the lines in a series spectrum. One feature, however, of these double "heads," or doublets, appears at first sight to differentiate them from the doublets found in line spectra, and one purpose of the present paper is to show that the difference in character is only apparent, and that the formal analogy with line spectra extends very far. It was shown by Fowler that the less refrangible components can be arranged in series of a very ordinary simple form, that of Rydberg being almost sufficient. But the more refrangible components cannot be arranged in a satisfactory manner, even in a Hicks series. They are, in fact, an example of a phenomenon not unknown in line spectra, where lines which obviously belong to a series cannot be fitted in a satisfactory way into the usual formulæ, because these formulæ do not, in these individual cases, converge with sufficient rapidity. The present paper shows that this approximate superposition of two series with the same limit, but with very different modes of convergence among their coefficients, is the cause of the unusual character of the doublet separations. Formulæ are calculated for the two series. A. W.

1258. *Excitation of Band Spectra in Nitrogen and Carbon.* **R. Seeliger.** (Phys. Zeits. 16. pp. 55–59, Feb. 15, 1915. Communication from the Physikal.-Techn. Reichsanstalt.)—An investigation into the mechanism and seat of light-emission of gases by the variation of the type of excitation. Gehrcke's method of using slowed kathode rays has been improved, especially as regards the length of exposure necessary, and used for obtaining simultaneously photographs of the gaseous spectra produced on excitation by fast and slow kathode rays and by canal rays.

The nitrogen spectrum in the visible, which comprises two positive groups and one negative, has the former alone strongly excited by slow kathode rays (velocity < 20 volts), whilst fast kathode rays produce only weak excitation, and the canal rays are non-effective. On the other hand, the negative band is markedly affected by fast kathode rays and considerably less by slow kathode rays and canal rays.

The bands of carbon and its compounds show no difference in their behaviour to fast and slow kathode rays, whilst canal rays weakly excite the CN-, (C + H)-, and the Swan-bands, but not the CO-band.

The results are discussed in the light of Stark's views on the source of band spectra. In carbon compounds band spectra arise from the molecules which can be excited but not dissociated by electrons (kathode rays). A certain stability of the molecules is necessary, as in CN- and certain (C + H)-compounds, to withstand excitation by canal rays. CO-compounds lack such stability. If, however, the positive bands of nitrogen are accredited to nitrogen molecules which can be dissociated by fast kathode and canal rays, and the negative bands to the atoms, a difficulty arises as to why the negative bands are more responsive to the fast kathode rays than to the slow rays. Some sort of additional hypothesis, such as "selective ionisation by impact," seems to be necessary. C. S. G.

1259. *Spectrum of Platinum.* **E. Paulson.** (Ann. d. Physik, 46. 5. pp. 698–704, March 16, 1915.)—Arranged in 84 groups, 175 lines of the Pt arc spectrum are here given. The 10 lines in each group, lettered A to J, have the following (mean) constant frequency-differences :—

B—A = 3065·72
C—B = 2006·20
D—C = 3365·33
E—D = 15·17
F—E = 3550·34
G—F = 427·52
H—G = 5318·09
I—H = 47·86
J—I = 776·17

One or more of the lines in each group are missing. A. W.

1260. *Zeeman-effects with Inclined Fields.* **W. Voigt.** (Ann. d. Physik, 47. 2. pp. 245–269, June 1, 1915.)—The phenomena to be expected are theoretically derived and are plotted in numerous complicated graphs which should be referred to in the original. E. H. B.

1261. *Spectra of Ruthenium.* **E. Paulson.** (Phys. Zeits. 16. pp. 81-84, March 1, 1915.)—Three whole-page tables of the lines of ruthenium with explanation of same and comments. E. H. B.

1262. *Crystal Structure and Interference of X-rays.* **R. Glocker.** (Ann. d. Physik, 47. 8. pp. 377-428, June 10, 1915. Extract of Inaug. Dissertation, Munich.)—By passing a narrow pencil of X-rays through various crystals, a series of photographs, of the type originally obtained by Laue, have been obtained. By a careful examination of the arrangement of these spots relative to the orientation of the crystal, the author has determined the structure of the space-lattices of several crystals, *e.g.* rock salt, sylvine, potassium bromide, and fluorspar. Accurate determinations have been made of the "grating spaces" of these crystals for different orientations. A. B. W.

1263. *Radiation produced by X-rays.* **J. Laub.** (Ann. d. Physik, 46. 6. pp. 785-808, March 30, 1915.)—In the experiments described an attempt has been made to obtain a relation between the intensity of the secondary radiation and the angle of incidence of the primary beam of X-rays. The connection between these two quantities is so marked that, when very thin sheets are used as secondary radiators, the intensity of the secondary radiation falls off to a very small quantity when the angle of incidence of the primary beam is less than 70°. This "angle-function," as the author calls it, varies with the hardness of the tube and the material of the radiator. In a special set of experiments it is shown that the variation of radiation intensity with angle of incidence is independent of the state of polarisation of the exciting primary beam. The manner in which the "angle-function" depends on the penetrating power of the primary X-ray beam has also been examined. Using the values tabulated in the paper, a calculation is made of the minimum penetrating power of the X-rays necessary for the production of secondary rays.

New characteristic radiations from iron, copper, zinc, platinum, lead, carbon and sulphur have been found, and their specific absorption coefficients in Al determined. The secondary rays from carbon and sulphur are shown to be the hardest characteristic X-rays yet discovered. A. B. W.

1264. *Production of X-rays by Slow Kathode Rays.* **E. R. Laird.** (Ann. d. Physik, 46. 5. pp. 605-622, March 16, 1915.)—Previous work on this subject has been published by numerous authors, including Wehnelt, Trenkle, Dember, and Whiddington. Dember [Abs. 1828 (1913)] has shown that soft X-rays, capable of blackening a photographic film, are produced by a kathode stream of velocity corresponding to a 200-volt p.d. In the present paper experiments on this very soft type of X-radiation are described. In addition a number of experiments have been made on the absorption in different substances of X-rays produced by a kathode stream of velocity 550 volts. The observations are summarised as follows:—(1) The production of X-rays by kathode rays of velocity less than 220 volts has been demonstrated in different ways. (2) Using different primary p.d.'s, the intensity of radiation has been determined by the liberation of secondary electrons and by ionisation currents. Above 450 volts it is found that the ratio of the energy of the incident X-rays to the energy of the kathode rays produced is almost constant. Below 450 volts, however, this is no longer the case. (3) The material of the antikathode has no influence on this soft radiation. (4) The radiation shows some indications of polarisation: the intensity appears to be a little greater in the direction normal to the kathode stream than parallel to it. (5) The experiments on the distribution of velocities of the secondary electrons produced by the soft X-radiation are incomplete, but they show the existence of electron velocities in the neighbourhood of 100 volts. (6) Some of the experiments throw doubt upon the work of other observers on the production of soft X-rays by kathode streams of velocity less than 200 volts. A. B. W.

1265. *Number of Electrons emitted from a Metal Plate exposed to Soft X-rays.* **E. Hoepner.** (Ann. d. Physik, 46. 5. pp. 577–604, March 16, 1915. Abstract of Dissertation, Greifswald.)—The method employed in this investigation is that adopted by Rutherford and Geiger for counting the number of α-particles emitted from a radio-active source. A beam of soft X-rays of small intensity is allowed to fall on a thin metal plate, each electron liberated producing a kick of the electrometer needle. In this way the total number of electrons per cm.^{2} emitted from the plate can be determined. The value found by the author for the number of electrons emitted by a Pt plate in a beam of X-rays, is only about 1/150 of the value which Carter [Abs. 291 (1907)] obtained from measurements of the *positive* leak from a Pt plate exposed to X-rays.

A description is also given of a series of experiments to show how the number of electrons emitted from the plate depends on the intensity of the X-radiation; the number emitted is found to be almost proportional to the intensity of the incident beam. No indication was observed of an "accumulation-time" for the electron emission produced by the X-rays, the emission being constant from the instant the X-ray beam is allowed to fall on the metal plate. A. B. W.

1266. *Hard Röntgen Rays.* **F. Dessauer.** (Phys. Zeits. 15. pp. 942–946, Dec. 15, 1914.)—Certain highly exhausted tubes give radiations approaching γ-rays in character. They form a very homogeneous band, and their absorption-coefficient is 0·14 for aluminium (as against 0·04 for γ-rays) rising with progressive increase in the atomic weights of the absorbents to 8·2 for gold. The divergences from the absorption-coefficients of γ-rays increase with rising atomic weights of the absorbents. A. D.

1267. *The X-ray Spectrum.* **A. Sommerfeld.** (Ann. d. Physik, 46. 6. pp. 721–748, March 30, 1915.)—A mathematical paper divided into the following sections: (*a*) General considerations on continuous and line spectra of X-rays and γ-rays; (*b*) Mathematical treatment of a single- and a double-period impulse; (*c*) Application of a statistical method to the consideration of the formation of X-rays; (*d*) The change of form of a single impulse on its passage through a thin layer of free electrons; (*e*) On the damping of free electrons and on the action of bound electrons.

The author summarises as follows:—With regard to the spectrum produced, a single impulse (electric force remaining of the same sign) is distinguished from a double impulse (the line-integral of the electric force equal to zero) solely by the intensity of the extreme long-wavelength radiation, which in the case of a single impulse is a maximum, and for a double impulse is zero. This difference cannot essentially become evident in the range of X-ray frequencies. The information available with regard to secondary radiation can give no decision against an initially "single" form of primary impulse. The result obtained by Lorentz for the composition of a large number (N) of irregularly distributed single or double impulses (resulting intensity proportional to N^2 or N) is derived from general statistical considerations. Consequently, to conclude that a single impulse will be neutralised by the excessive energy of the secondary radiation, it is necessary to assume that the form of the impulse remains single and unchanged by the spreading of the excited secondary electrons. In other words, the energy corresponding to the short wave-lengths would have to be transferred to the long wave-lengths in order to compensate for the "scattered" energy.

In order to transform a single impulse into a double impulse it is sufficient to pass it through a thin metal screen which absorbs the visible and infra-red radiations. The transformation takes place essentially without loss of energy.

A special example is given, in which this process of transformation can be followed by both numerical and graphical methods. This example is ideal in that it extends the simplifications of the ordinary dispersion theory to the region of the X-radiations. A. B. W.

1268. *X-rays and Crystal Structure.* **W. H. Bragg.** (Roy. Soc., Phil. Trans. 215. pp. 253–274, July 18, 1915. Bakerian Lecture.)—The paper commences with an interesting review of previous work bearing on the study of crystalline structure by the use of X-rays. The reflection of X-rays from planes rich in atoms, and the determination of the "grating space" and the dimensions of the elementary cell of a space-lattice, are considered from theoretical and practical standpoints. Coming to the principal topic of the paper, the author proceeds to discuss a method for the determination of the arrangement of the atoms of a crystal about a representative point. For this purpose it is necessary to know the relative intensities of the reflections of different orders and from different sets of planes. Measurements of this kind are much more difficult than measurements of "position" and their exact interpretation is also by no means clear. By way of illustration, the typical cases of rock salt, diamond and fluorspar are examined, the intensities of different orders and corresponding to different sets of planes of atoms being carefully compared.

The author considers it almost certain that two planes of atoms containing equal weights per unit area, are equivalent in reflecting power no matter how the weight is made up or distributed on the plane. Taking the case of iron pyrites, it is shown that there is a fundamental face-centred lattice of iron atoms, the sulphur lattices being displaced from it in the manner indicated. This displacement of the iron and sulphur lattices can be calculated from determinations of the relative intensities of the various X-ray spectra of iron pyrites. The more complex case of calcite ($CaCO_3$) is studied in a similar fashion and its exact structure determined.

The author suggests that the observed rapid diminution of intensity in the high-order spectra may be explained on the hypothesis that the scattering power of the atoms is not localised at one central point in each, but is distributed through the volume of the atom. It is to be expected that the scattering centres of the atom are not only diffused in this way through its volume, but are also less dense at the edges than at the centre, thus producing exactly the conditions which would reduce greatly the intensities of the higher orders of the spectra. A provisional quantitative estimation of the operation of this principle shows that the fraction of the atom which is effective is $a^2c^2/(a^2c^2 + n^2\pi^2)$ where $2a = d$, the "spacing" of the atom planes, ac being a measure of the overlapping of two atoms. It will be seen from this relation that when a^2c^2 is small compared with $n^2\pi^2$ the intensity varies as n^2, when a is constant, and as a^2 when n is constant. In actual practice it is found that the intensity of any spectrum is proportional to $1/\sin^2 \theta$, where θ is the glancing angle, no matter whether the spectra belong to one or several spacings of the planes. This involves essentially the two theoretical deductions just given. It is suggested that, using the methods indicated in the paper, it should be possible to determine the distribution of electrons in the atom. The paper concludes with a consideration of one or two subsidiary points regarding crystals in which the atoms are not all alike and are spaced irregularly. A. B. W.

1269. *X-ray Spectra.* I. **E. Wagner.** (Ann. d. Physik, 46. 6. pp. 868–892, March 30, 1915.)—The paper commences with a brief outline of previous work on the subject. After reviewing the work of de Broglie, using a photographic method with stationary and rotating crystals, he proceeds to consider the researches of Bragg [Abs. 1840 (1914)], in which the intensities of the various spectrum lines were measured by an ionisation method. The most suitable disposition of X-ray tube, slit, crystal and photographic plate are discussed and an interesting description is given of the method of rotating the crystal. Using a hard X-ray tube with a tungsten antikathode a series of photographs have been obtained showing the absorption spectra of various elements. Thus reproductions of photographs are given showing the effect of introducing varying thicknesses of the metals Sn, Cd, Ag, and Pd in the path of the X-rays. The following table includes a series of measurements of the wave-lengths of the absorption bands for different elements. λ_A is the wave-length, in 10^{-8} cm., of the absorption band of the K-series, λ_{A_1} and λ_{A_2} being the two absorption bands of the L-series. The remaining columns contain the characteristic "emission" lines measured by Moseley, and some theoretically interesting wave-length ratios.

I.—K-SERIES.

Element.	λ_A.	λ_a.	λ_β.	λ_a/λ_A.	λ_a/λ_β.
Sn	0·425	0·488	—	1·148	—
Cd	0·468	0·536	—	1·145	—
Ag	0·490	0·560	—	1·143	—
Pd	0·518	0·586	0·523	1·136	1·130
Br	0·926	1·060	—	1·145	—
Cu	1·386	1·549	1·402	1·116	1·105
Ni	1·502	1·662	1·506	1·106	1·104
Fe	1·759	1·946	1·765	1·106	1·103

II.—L-SERIES.

Element.	λ_{A_1}.	λ_{A_2}.	λ_a.	λ_γ.	λ_a/λ_{A_1}.	λ_a/λ_γ.	λ_a/λ_β.	$\lambda_{A_1}/\lambda_{A_2}$.
Pt	1·072	0·934	1·316	1·104	1·23	1·20	1·17	1·15
Au	1·042	0·914	1·287	1·078	1·23	1·19	1·18	1·14

From Table I the author shows that Stokes' law holds for the whole K-series. The ratio λ_a/λ_A is essentially constant for different elements; the nearer in atomic weight these elements are to one another, the more exactly does this observation hold good. Similarly with the ratio $\lambda_\alpha/\lambda_\beta$. In this way the author brings out a striking parallelism between the absorption and emission. A similar treatment is given for the L-series.

Several other interesting observations on absorption and emission spectra of X-rays are discussed. A. B. W.

1270. *Spacial Representation in X-ray Photography.* **B. Alexander.** (Phys. Zeits. 16. p. 141, April 15, 1915.)—X-ray photographs, as a general rule, appear to be without depth, that is, they appear merely as shadows cast by a two-dimensional object. The author reproduces a series of photographs showing the ease with which it is possible to obtain X-ray photographs of a stereoscopic nature. Using a coil of metal gauze photographs are shown which certainly suggest a three-dimensional object. A. B. W.

1271. *Scattering of X-rays.* **P. Debye.** (Ann. d. Physik, 46. 6. pp. 809–823, March 30, 1915.)—A mathematical paper dealing with the following points: (1) The energy scattered from a very large number of electrons. (2) Scattering produced by a large number of molecules with rings of electrons. (3) Discussion on the distribution of intensity of the scattered radiation and its relation to Friedrich's interference. A. B. W.

1272. *Application of Selenium to the Measurement of the Energy of Röntgen Rays.* **F. Voltz.** (Phys. Zeits. 15. pp. 209–212, June 1, 1915.)—The principle that selenium changes in electrical resistance when it absorbs light-energy has been used in the construction of various photometers. The author now describes an investigation on the possibility of this principle being extended to the measurement of X-radiation. It is shown from the observations that selenium is unsuitable for the ready measurements of X-ray intensities. The values of the energy, deduced from resistance observations, are strongly affected by many factors, *e.g.* "time" and "frequency." Again, the selective absorption of selenium for X-rays of absorption coefficient 18·9 (characteristic of Se) introduces a further difficulty. The mean value deduced from a considerable number of observations of the energy measured with a selenium cell is seen to be practically valueless when compared with the value as measured by an ionisation method. A. B. W.

1273. *Electrical Density and Absorption of β-Rays.* **F. Sanford.** (Science, 42. pp. 130–131, July 23, 1915.)—The object of this paper is to show that the absorption coefficient of the elements for β-rays is dependent rather upon the electrical density (λ/D_e) of the absorbing agent than upon its mass density (λ/ρ). By "electrical" density (λ/D_e) is meant the ratio of atomic charge to atomic volume. A table is given which shows that the values of λ/D_e for a large number of elements, vary much less than the values of λ/ρ for the same elements. This point is also indicated graphically. A. B. W.

1274. *Radium Emanation in the Atmosphere.* **J. R. Wright** and **O. F. Smith.** (Phys. Rev. 5. pp. 459–482, June, 1915.)—A detailed description is given of a determination of the variation with the meteorological conditions of the amount of radium emanation in the atmosphere, in the soil gas, and in the air exhaled from the surface of the ground, at Manila (Philippine Islands). The method used for the estimation of the emanation had its origin in Rutherford's discovery that coconut charcoal absorbs emanations readily, and was essentially that used by Eve and Satterly [Abs. 1964 (1908)] in similar investigations. From a consideration of a large collection of tabulated observations it is shown that the variation of the Ra-content of the atmosphere follows quite closely the variations in rainfall and wind movements. The mean value obtained for the radium equivalent of the emanation per $m.^3$ of air is $71{\cdot}0 \times 10^{-12}$ gm. No direct connection has been observed between the emanation content and atmospheric pressure or humidity. A decided diurnal variation has been found to exist, the emanation content being considerably greater during the night than during the day (the mean ratio being 3·81). The rate at which radium emanation is exhaled from the ground shows a decided decrease after periods of heavy rain. This decrease has been found in some cases to be almost 60 % of the rate of exhalation for fair weather.

The RaEm-content of soil gas has been determined for depths of 30, 70, and 120 cm. respectively, and the variation with weather conditions studied. The variation in the radio-activity of the gas from the 30-cm. pipe was found to follow closely the variation of the emanation exhaled, a decrease in the exhalation resulting in a corresponding increase in the emanation-content of the ground gas. The 70-cm. and 120-cm. pipes showed only slight variations with the weather conditions. The average value of the emanation-content of the gas from the 120-cm. pipe was found to be $304{\cdot}5 \times 10^{-12}$ cm. per litre, or over 4000 times the mean value for atmospheric air. The mean value for the 30-cm. pipe was only about one-seventh that for the 120-cm. pipe.

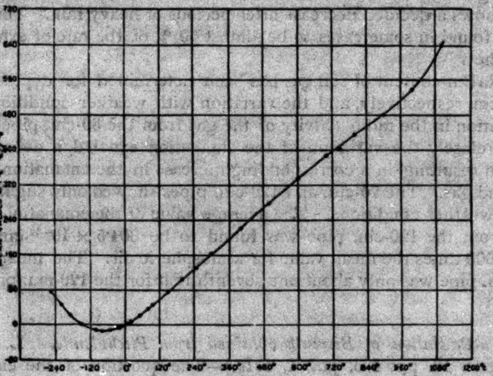
A. B. W.

1275. *α-Radiation of Bismuth obtained from Pitchblende.* **L. Meitner.** (Phys. Zeits. 16. pp. 4–6, Jan. 1, 1915.)—The question of the end product of the radio-active series has been revived by the discovery that lead derived from Ur minerals differs in atomic weight from ordinary lead, for Richards and Lembert have found values for the atomic weight of the lead in pitchblende residues appreciably less than that of ordinary lead [Abs. 1751 (1914)]. Fajans has suggested the following scheme: $Pb \xrightarrow{\beta} Bi \xrightarrow{\alpha} Tl$. Meitner has now investigated the α-radiation of Bi derived from Joachimsthal pitchblende, and finds that the activity does not belong to the Bi itself, but can be completely separated from it. Using the ordinary decay method it was found that the whole α-activity arises from ionium accompanying the bismuth preparations. Consequently all the conclusions which have been based on the α-activity of Bi must be regarded as invalid. A. W.

1276. *Radiations from Exploding Atoms.* **E. Rutherford.** (Engineering, 99. pp. 657–659, June 11, 1915. Lecture delivered before the Royal Inst. Electrician, 75. pp. 363–364, June 11, 1915. Nature, 95. pp. 494–498, July, 1915.)—Deals, in the light of recent work, with the phenomena which spontaneously arise in the break-up of radio-active atoms. L. H. W.

HEAT.

1277. *Cubical Expansion of Vitreous Quartz.* **N. E. Wheeler.** (Roy. Soc. Canada, Trans. 8. pp. 139–156, 1914.)—An accurate knowledge of the coefficient of dilatation of quartz at different temperatures is of great importance in thermometry, and this paper forms a *résumé* of the more important work done in this subject. The results obtained up to 1911 have been given in the paper by G. W. C. Kaye [see Abs. 98 (1911)]. It appears to be unsafe in the case of quartz to assume that the coefficient of dilatation is 3 times the coefficient of linear expansion. Finally the results of the most reliable work are tabulated and shown graphically in the Fig. reproduced herewith.



J. W. T. W.

1278. *Thermal Conductivity of Lead.* **T. Peczalski.** (Comptes Rendus, 160. pp. 766–768, June 14, 1915.)—It has been shown, in the case of certain dielectrics and of bismuth, that the coefficient of thermal conductivity is constant if the temperature is measured on the exponential scale, *i.e.* it is inversely proportional to the absolute temperature on the ordinary scale. This paper describes an experiment made for the purpose of extending the law to the thermal conductivity of lead. A hollow sphere of lead (radii 3·65 and 7 cm.) was filled with water and placed in a large water bath maintained at a constant temperature. The water inside the sphere was heated electrically at a constant rate, and the steady temperature-difference (1·25° C.) between the inside and outside surfaces was measured with a German silver and lead thermo-junction. The results showed that the law held within the limits of temperature investigated (11°–37° C.).

Temperature (absolute)	284·5°	295·2°	309·9°
K (ordinary scale)	0·0896	0·0863	0·0826

These values of the coefficient are rather higher than those found by previous observers. D. O. W.

1279. *The Two Specific Heats of Liquids.* **D. Tyrer.** (Zeits. Phys. Chem. 87. pp. 169–181, 1914.)—In continuation of the researches on the adiabatic and isothermal compressibilities of some liquids between one and two atmos. (J. Chem. Soc., Trans. 104. pp. 1675–1688, 1913) the author determines and calculates the c_p, c_v, and c_p/c_v of benzene, toluene, chloroform, carbon tetrachloride, carbon disulphide, ether, chlorobenzene, ethylalcohol, and water at temperatures between 0 and 100°. The ratio c_p/c_v is much higher for a liquid than for its vapour; the ratio is fairly constant at different temperatures, except in the case of CS_2, which has the highest value of the normal substances, whilst ether and chlorobenzene have the lowest; the value is low for alcohol and water because their molecules are complex. When the molecular attraction is expressed by a/v^2 (after van der Waals), de Heen's hypothesis as to the change of $(c_p - c_v)$ with temperature does not hold, but $(c_p - c_v)v^2/(dv/dt)$ is found constant for normal liquids, for which the product $(c_p - c_v) \times$ molecular weight is constant at the same temperature. The latent heat l is approximately given by $l(dv/dt)/v(c_p - c_v) = 1$. H. B.

1280. *Influence of Röntgen Rays on the Condensation of Water-vapour, according to C. Leibfried and O. Conrad's Experiments.* **F. Strieder.** (Ann. d. Physik, 46. 7. pp. 987–1008, April 20, 1915. Inaug. Dissertation, Marburg, 1914 and 1915.)—The condensation of water-vapour in presence of pure gases, dust-containing gases, ions, chemical compounds and hygroscopic substances, and the nature of blue fog are first discussed [compare Wilson, Abs. 662 (1899), 1025 (1900); Bieber, Abs. 1101 (1913)]. In air, but not in hydrogen, the action of Röntgen rays produces condensation nuclei far below the limit of appearance of ions. In oxygen spontaneous condensation of water-vapour is readier than in air, but in pure nitrogen no blue fog and no spontaneous condensation are obtainable.

It has been shown by Bieber that the blue fog nuclei produced by ultra-violet light consist of hydrogen peroxide, and it may safely be assumed that the same is the case with Röntgen rays. The oxygen molecules are doubtless resolved by the rays into atoms, which then form hydrogen peroxide with the water. T. H. P.

1281. *Vapour-pressure Lines of the System Phosphorus.* IV. **A. Smits** and **S. C. Bokhorst.** (K. Akad. Amsterdam, Proc. 18. pp. 106–116, July 13, 1915.)—The results previously obtained seemed to indicate that the vapour-pressure curve of liquid white phosphorus could not be regarded as the metastable prolongation of the vapour-pressure curve of the liquid violet phosphorus. Owing to the possibility of errors in the values obtained for the vapour-pressure of white phosphorus at high temperatures, new measurements have been made in a special form of apparatus, the temperature of the phosphorus itself and not that of the surrounding bath being determined. The results show that the previous determinations were vitiated by the spontaneous heating of the white phosphorus in its exothermic conversion into the violet modification. The curve representing the values of $T\ln p$ as a function of T is found to be very slightly concave towards the temperature axis and to correspond with the curve for the liquid violet phosphorus, although the intermediate part could not be realised. The two curves are in satisfactory agreement with the expression, $T\ln p + 3{\cdot}59\ T\ln T = 37{\cdot}62\ T - 8257$.

It follows that phosphorus is not of the same type as cyanogen and that liquid white phosphorus must be regarded as supercooled liquid violet phosphorus, so that the system phosphorus can be represented in a simpler way than was formerly thought possible. The differences in properties between white and violet phosphorus suggest that the latter contains a much larger proportion of associated molecules than the former. T. H. P.

1282. *Calculation of Vapour-pressure Curves.* I. **I. W. Cederberg.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 7. pp. 1–71, 1914.)—With reference to the dependence on the temperature of the factor a of van der Waals' vapour-pressure formula [see Abs. 1694 (1914)], the author points out the great influence of an error in the experimental critical magnitudes on the position and form of the a–T curves. It is assumed that these curves are symmetrical about a straight line perpendicular to the T-axis and passing through the minimum. This assumption is confirmed in very many instances, and other cases are brought into agreement with it by alteration of the observed critical pressure by an amount less than the probable experimental error. T. H. P.

1283. *Vapour-pressure of Liquids in Presence of Gases.* **F. H. Campbell.** (Faraday Soc., Trans. 10. pp. 197–206, May, 1915.)—The author has devised an apparatus for the statical determination of the vapour-pressure of pure and mixed liquids over a considerable range of temperature, and has obtained with it results which are in good agreement with those generally accepted as standard. From his experiments, the author proves that liquids exert a lower vapour-pressure in presence of gases than when in contact with their own saturated vapours only. In the case of any one liquid, this lowering is greater the more soluble the gas, and the lowering appears to be related to the solvent power of the liquid. The amount of gas dissolved, however, is quite insufficient to account for the whole of the observed lowering, and the differences tend to disappear when the liquid is violently agitated. It is suggested that the concentration of a gas in an unstirred liquid is much greater at the surface than in those parts of the liquid removed from the influence of the forces which are operative there. A. F.

1284. *Spontaneous Temperature-fluctuations in a Gas.* **F. v. Hauer.** (Ann. d. Physik, 47. 8. pp. 865–876, June 10, 1915.)—Since the velocities of gas molecules differ from each other, the chance will occur for accumulations of quicker- and slower-moving molecules in different portions of a gas volume, *i.e.* for deviations at isolated places from the average temperature. The present paper contains a mathematical investigation and calculation of such temperature fluctuations. A similar and more general problem has already been dealt with by Einstein, who, starting from the Boltzmann formula $S = k \, . \log W$, derived the probability dW that a physical system defined by co-ordinates $\lambda_1 \ldots \lambda_n$ is in such a state that the quantities λ have values between λ_1 and $\lambda_1 + d\lambda_1 \ldots \lambda_n$ and $\lambda_n + d\lambda_n$, to be $dW = e^{(s - s_0)/k} f d\lambda_1 \ldots d\lambda_n$, where S is the entropy of the system in this state, S_0 the entropy in the state of ideal thermodynamic equilibrium, k the Boltzmann constant, and f a function of the quantities λ. The application of this general formula to the current problem and a comparison between the results from this and the author's method of treatment also forms part of the paper. For the case of very small gas-volumes where the number of molecules is no longer large, the entropy principle loses its force, causing Einstein's formula to become only an approximation, and the author employs Maxwell's law for calculation purposes. From this standpoint he investigates in detail the probability of any portion of the gas containing n molecules deviating from the average temperature T, taking cases of 2, 3, 4 ... n molecules. The most probable deviation ΔT is found to be given by the formula $\Delta T^2 = T^2 2/3n$, where T is the absolute temperature, when the number of molecules is not less than 10^6. This expression is also found to be given by Einstein's formula when applied to volumes containing a large number of molecules.

The paper concludes with some speculations on the thermal condition of the Universe. H. H. Ho.

1285. *Total Radiation from Metals.* **V. A. Suydam.** (Phys. Rev. 5. pp. 497–509, June, 1915.)—With many substances the total radiation can be expressed with fair accuracy by a simple relation of the form $E = c'T^n$. In the case of some metals and alloys, however, this equation does not express the radiation accurately. The character of the surface of the body and its internal structure are factors which affect radiation, and as these vary with the temperature, it is to be expected that the emission cannot always be expressed so simply. From an application of Kirchhoff's law, which may be written $f(T)/cT^4 = a(T)$, coupled with the fact that $a(T)$ is a function of the temperature in most cases [see Abs. 948 (1910)], it is easily seen that $f(T)$ is not equal to $c'T^4$. The coefficient of electrical resistance is positive when metals are in the solid state, and hence $a(T)$ increases with T, approaching unity as a limit. Hence metals approach black-body radiation with increase in temperature. The present investigation shows that glass, brass, and lamp-black are better absorbers at high than at low temperatures. In the case of all the metals tested, Ag, Pt, Ni, Fe, and the alloy nichrome, n in the equation $E = c'T^n$ was found to be greater than 4. Tables are given of the results and also graphs of the energy-temperature relations. A. W.

1286. *On the General Theory of Corresponding States, and the Thermodynamic State Equation.* **G. v. Kaufmann.** (Phil. Mag. 29. pp. 146–162, July, 1915.)—Part I of this paper deals with the analysis and generalisation of the theory of corresponding states, and a new method of obtaining the reduced state-equation. This theory, based upon van der Waals' equation, was at first regarded largely in the light of molecular theory, to which it owes its origin. Its consequences are, however, so important and so extended that the empirical side of it soon came into the forefront, and as a result it was realised that the theory of corresponding states follows not only from van der Waals' equation, but from any state-equation with not more than three specific constants. Meslin first showed this to be a purely mathematical consequence. Furthermore any "critical point" thus defined by general equations will serve the same purpose, and Berthelot set up reduced equations on the basis of three other critical points which have certain special thermodynamic properties defined analytically. Although in many cases a fairly approximate correspondence of states has been found to exist, the theory in its entirety is inexact, not having been found completely true for even a single pair of substances. There is therefore no general (p, v, T)-state-equation with only three specific constants, but since so far-reaching and fundamental a theory as this gives a good first approximation to the facts, attempts are being made to modify it into more general agreement with the truth. The author here gives a re-statement of the fundamental principles of the theory of corresponding states from a rather different and more general point of view, and a suggestion as to the direction in which the true nature of the generalities certainly existing is to be sought. In addition there is indicated an extension of the theory to phenomena involving other than the purely thermodynamic quantities p, v, T. The method is to apply to van der Waals' equation the purely algebraic process of reducing an equation $F(x, y, z, \ldots, \alpha, \beta, \gamma) = 0$, which contains r specific constants $\alpha, \beta, \gamma, \ldots$, and which connects variables $x, y, z, \ldots$, involving n independent dimensions, to a non-dimensional form, containing n specific constants less than the original. This method, while essentially similar to the old one, directly expresses the theory of corresponding states, and gives a reduced equation involving those obtained by the use of any critical points, in all their consequences: it is the simplest form and the most general, while it enables the application of the theory of corresponding states to other phenomena not involving easily recognisable critical points. The various systems correspond proportionally with respect to given quantities, corresponding states being defined by equal values of certain fixed specific ratios of the quantities. The mathematical condition for this proportional correspondence is that the number of specific constants in the equation connecting the quantities be not greater than the number of independent dimensions. The geometrical expression is the superimposability of the logarithmic curves and surfaces, as shown by Raveau for the (p, v, T)-state-equation, and this logarithmic test is the answer to any objections laid against the purely theoretical side of this generalisation. Several examples are given by the author of this extension of the theory of corresponding states to the most diverse phenomena in physics and chemistry.

Part II of this paper deals with the calculation of the complete conditions of liquid-vapour coexistence from the state equations of van der Waals, D. Berthelot, and Clausius. The problem of calculating the equations connecting temperature, pressure, and coexisting volumes in the two-phase system, from the (p, v, T)-state-equation for the homogeneous substance, has received very little attention hitherto. Theoretically, a solution is to be obtained from the thermodynamic equation of Maxwell and Clausius, $\int_{v_2}^{v_1} p \, . \, \partial v = p(v_1 - v_2)$, together with the state equation applied to each of the coexisting volumes: $F(p, v_1, T) = 0$, $F(p, v_2, T) = 0$. In practice the solution offers some difficulty, and this, together with the fact that all the well-known state equations are known to be inaccurate at temperatures below the critical point, accounts, no doubt, for the long neglect. The author here gives details of a process based on a method due to Planck, and tabulates a series of functions derived from the above-mentioned state equations. Particularly simple expressions are obtained for Mr/RT (r being the latent heat) and $d \log p / d \log T$, which is of interest, since the former is the well-known Trouton's constant, divided by $R = 1{\cdot}985$, and the latter is closely related to Crafts' correction constant for boiling-point under different atmospheric pressures. A table showing the relation of Trouton's constant and Crafts' as experimentally determined for about 40 substances concludes the paper.

H. H. Ho.

1287. *Theory of Radiation.* **W. Wien.** (Ann. d. Physik, 46. 6. pp. 749–752, March 20, 1915.)—A mathematical discussion based on the relation for an electron $\frac{1}{2}mv^2 = h\nu$. The author shows that the law of radiation thus obtained reduces to the Rayleigh-Jeans law for $\nu = 0$ and $U = kT$. E. H. B.

1288. *Dynamical Significance of Planck's Element of Action.* **R. Schachenmeier.** (Ann. d. Physik, 47. 1. pp. 128–140, May 11, 1915.)—Starting with Planck's equations for a linear oscillator the author by a series of transformations derives the following expression for Planck's universal constant—

$$h = \frac{1}{8} ml \frac{V}{\zeta} \cdot \frac{1}{Q},$$

where m is the mass at the positive pole of the dipole, l the mean free path, ζ the number of corpuscles in volume V, and Q is an integer. Thus h is the element of action which carries the oscillator over from one state of resonance into a neighbouring state and is linked with the region element of probability. E. H. B.

1289. *Einstein's Energy Variations.* **M. v. Laue.** (Deutsch. Phys. Gesell., Verh. 17. 10. pp. 198–202, May 30, 1915.)—A theoretical discussion of Einstein's views as to the variations of energy of a system of monochromatic independent resonators as treated by Planck in his hypothesis of quanta. E. H. B.

1290. *Relation between Sommerfeld's Principle of Action and Planck's Quantum Theory.* **M. Wolfke.** (Phys. Zeits. 16. pp. 207–209, June 1, 1915.)—A mathematical treatment to show that Sommerfeld's principle of action is contained as a special case in the more general principle as enunciated by Planck in his "Dynamics of Moving Systems." E. H. B.

1291. *Surface between a Liquid and its Saturated Vapour.* **C. A. Mebius.** (Phys. Zeits. 16. pp. 121–127, April 1, 1915.)—A general treatment of the phenomena associated with the surface of separation between a liquid and its saturated vapour. A. W.

1292. *Theoretical Determination of the Entropy Constant of Gases and Liquids.* **H. Tetrode.** (K. Akad. Amsterdam, Proc. 17. pp. 1167–1184, April 28, 1915.)—Mathematical. T. H. P.

SOUND.

1293. *Vibrations of Electrically Glowing Platinum Wire.* **F. Streintz** and **A. Wesely.** (Phys. Zeits. 16. pp. 85–86, March 1, 1915.)—A tuning-fork is imitated by two Pt-wires electrically incandescent in place of the prongs. This is then set in vibration and photographed. The ten reproductions show the fundamental vibrations and some of higher orders. E. H. B.

1294. *Vibrations of Wires carrying Currents.* **F. Streintz.** (Phys. Zeits. 16. pp. 187–188, April 15, 1915.)—If alternating currents are passed through a freely hanging Pt-wire transverse vibrations occur which are specially striking when the wire is incandescent [see preceding Abs.]. The question then arises as to whether these vibrations so plainly visible could be replaced by others which are audible. This was quickly accomplished. Instead of fine wires, iron wires of 0·3, 0·6 and 1·5 mm. diam. were used, and of lengths twice 75 cm. to twice 175 cm. A weight was also added to the wire and then increased, and the effects noted. In this way the first ten partials were obtained of the fundamental E. E. H. B.

1295. *Repeated Sounds from Ball or Shell.* **Agnus.** (Comptes Rendus, 160. pp. 733–736, June 7, 1915. Extract.)—Refers to the phenomenon, familiar to many since the outbreak of the war, of the repeated sounds of a ball or shell when fired with a velocity greater than that of sound. An observer ahead of the gun and not too far from the line of fire hears this repeated sound; and this is explained by diagrams, showing that the first sound to arrive is that proceeding almost in the direction of the projectile and at a speed greater than the normal speed of sound, while the second sound to arrive is that from the source at the normal speed. If, on the other hand, an observer is well off the track of the projectile he receives no sound at a higher speed than normal, and hears only the usual whistling. E. H. B.

1296. *The Theory of Audition.* **A. Stefanini.** (N. Cimento, 9. pp. 149–196, March–April, 1915.)—An exposition of all the theories proposed, with an elementary paraphrase of v. Helmholtz's treatment of the subject. The author arrives at the conclusion that with small modifications v. Helmholtz's theory holds the field. A. D.

1297. *Solid Vibrations of the Voice used in Telephony.* **J. Glover.** (Comptes Rendus, 160. pp. 685–686, May 25, 1915.)—States that advantage has been taken of the vibrations of the solid parts of the body which are excited by the human voice, and their employment in telephony secured. The apparatus for this purpose is said to be very simple, but is neither illustrated nor described. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

1298. *Determination of the Elementary Charge of Electricity.* **J. Kunz.** (Archives des Sciences, 39. pp. 488–498, June, 1915.)—Describes a determination of the elementary charge of electricity by means of the ferromagnetic properties and the magneton. The author has used Weiss's extension of Langevin's theory of magnetism to determine absolute values of elementary magnetic moments of iron, nickel, and magnetite [Abs. 858 (1910)]. From these values the elementary quantity of electricity e can be obtained. The mean value of e determined in this way for Fe, Fe_3O_4, Ni, Co, and two Heusler alloys is $1{\cdot}58 \times 10^{-20}$. The latter part of the paper discusses the magneton, reference being made to results obtained by Weiss, Piccard, Onnes, and Perrier. It appears that the values of the elementary magnetic moments determined by Langevin's theory are of the same order of magnitude as the theoretical value based on Planck's quantum h. The author considers that the question whether the magnetons of different substances are identical or variable has not up to the present been decided. A. W.

1299. *Motion of an Electrical Particle in a Constant, Rotating Magnetic Field.* **C. A. Mebius.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 10. pp. 1–9, 1914. Ann. d. Physik, 46. 7. pp. 1013–1020, April 20, 1915.)—A mathematical treatment arriving at the conclusion that the rotation of the magnetic field has, in general, the following effect on the motion of the electrical particle. Instead of a single linear vibration in a plane, there are in this plane two circular vibrations, one with a greater, and one with a smaller frequency than that in the stationary field. The relation is accordingly analogous to the resolution of a plane-polarised ray of light into two oppositely rotating circularly polarised rays. E. H. B.

1300. *Dimensions of Electric Measurements.* **H. Maurer.** (Elektrot. Zeits. 36. pp. 228–230, May 13, 1915.)—The difference between the electrostatic and the electromagnetic systems of measurement arises from an inadvertence in the statement of Coulomb's Law. In this the constant of proportionality is treated as a pure number, whereas it should have the dimensions of a velocity squared. With this correction the difference disappears, everything being measured in e.-m. units. Electrostatic capacity, $C = r$, acquires dimensions T^2/L, but this is $r \, . \, T^2/L^2$, where r the radius and L have nothing to do with one another. A. D.

1301. *Number of Electrons concerned in Metallic Conduction.* **G. H. Livens.** (Phil. Mag. 29. pp. 105–112, July, 1915.)—The author refers briefly to the work of Nicholson and of H. A. Wilson [Abs. 859 (1912); 1320 (1911)]. Nicholson concluded that the form of theory proposed by Wilson is not only the only theory which provides results consistent with those obtained experimentally, but also that this theory provides a very exact estimate of the required number of electrons. It now appears that Wilson's theory is incomplete and the formulæ he obtains and which are used by Nicholson are certainly not those which should follow from his fundamental assumptions. The present author here applies the theory of the optical properties of metals, which he has developed in a recent paper [Abs. 685 (1915)], to the calculation of the number of free electrons. In the author's opinion, precision of the degree expected by Nicholson cannot be obtained with the data at present available. I. W.

1302. *Electron Theory of Metallic Conduction.* III. **G. H. Livens.** (Phil. Mag. 29. pp. 112–124, July, 1915.)—This paper is one of a series of mathematical papers by the author. I. W.

1303. *Electric Strength of Solid Dielectrics.* **W. M. Thornton.** (Phil. Mag. 29. pp. 124–136, July, 1915.)—The electric polarisation of insulators has in general two terms: an externally forced displacement and a subsequent slower movement caused by interaction between polarised elements [Abs. 612 (1910)]. Electric breakdown occurs when the total displacement and energy stored exceed a certain limit, different for each material. The relation between thickness and breakdown voltage is given by the equation $t = Av + Bv^2$, where t = thickness and A and B are constants. This equation was tested for glass, mica, porcelain, vulcanised rubber, impregnated jute, press-board and oiled canvas; the agreement was very good. Since this equation holds it follows that the work done in breaking down any solid dielectric is constant for that material and is independent of the thickness. The author then discusses theoretically the causes of this law, and concludes that the extra displacement caused by interattraction should be the same as that initially produced by the applied field. The total displacement is therefore proportional to the applied field at breakdown. The influence of frequency is discussed. The internal field is on the average about twice as great as the external field. The external breakdown voltage, therefore, although it roughly differentiates between good and bad insulators, gives no indication of the atomic forces under which a material fails. Rupture is chiefly an internal effect, an electric explosion or recombination of atomic charges of such violence that the molecular structure is permanently damaged along the line of action. That electric breakdown is of the nature of an explosion along the line of failure is supported by the appearance of the point of passage of the spark, which has a burr at both ends, and by the fact that in many cases, unless the testing transformer or generator is large, a spark "through" insulation is not followed by permanent breakdown of insulation resistance. The insulation resistance, on the contrary, may actually be improved by the passage of a spark intended to break down an incipient fault. The amplitude of electrical displacement is calculated, and it is shown that a very small displacement relatively to the diam. of a molecule is sufficient to strain the atomic structure to breaking-point. The energy required to break down a single chain of molecules of sectional area 2×10^{-15} cm.^{2} in the typical insulators considered is of the mean order of 10^{-11} erg. The energy required to ionise a hydrogen atom is $1{\cdot}7 \times 10^{-11}$ erg. I. W.

1304. *Shape of Equipotential Surfaces near Long Walls or Buildings and Effect on the Measurement of Potential Gradient.* **C. H. Lees.** (Roy. Soc., Proc. 91. pp. 440–451, July 1, 1915.)—A theoretical investigation into the deflection of the equipotential surfaces, produced by walls and buildings with flat roofs, the ground being assumed to be a level plane and the undisturbed gradient to be constant for some distance above it; that is, the effect of the free ions in the lower layers of the atmosphere is neglected. The first case considered is that of a long thin vertical wall standing alone on a horizontal plane. Formulæ are worked out for the potential and the results are shown by a diagram of the equipotential surfaces and a table showing the vertical potential gradient near the ground at different distances from the wall. At a distance from the foot of the wall equal to its height *h*, the gradient will be 0·707 of the undisturbed value; at distance 5*h*, 0·981; that is, at this distance the wall will only reduce the potential gradient by 2%. A point of practical interest is that at a position approximately 8/10 of the way down from the top of the wall the horizontal gradient measured outwards will be equal to the undisturbed gradient measured vertically upwards from the surface of the plane.

In the second case considered a long vertical retaining wall separates two horizontal plane surfaces which lie at different levels. This case represents the conditions near to the wall of a large house with a flat roof.

The third and last case taken is that of a regular series of long parallel walls stretching across a plane. The conditions obtaining between a pair of these walls will represent with fair accuracy those which exist in a street with buildings on each side of it. When the height of the walls is 3/4 of their distance apart the vertical potential gradient midway between a pair of them will be only 0·18 of the normal undisturbed gradient, showing what a large effect such walls have in reducing the gradient. J. S. Di.

1305. *Electricity of Atmospheric Precipitation.* **G. C. Simpson.** (Phil. Mag. 29. pp. 1–12, July, 1915.)—While there are still certain questions relating to the electrical state of precipitation which have not been answered definitely, the broad features are now generally agreed upon by all observers. To account for these features two theories have been put forward: (*a*) The Influence Theory of Elster and Geitel; and (*b*) Simpson's "Breaking Drop" Theory. In the present paper these two theories are considered, particularly with reference to the manner in which they will explain the observed facts. Elster and Geitel's influence theory (*a*) is based upon the idea that small water-drops can come into electrical contact with large ones without uniting with them. Simpson considers that this supposition is far from established, and further suggests that even if sound it will not satisfactorily account for the electrical phenomena observed during rain. When the breaking drop theory (*b*) was first put forward, evidence was adduced to show that it fully accounted for the electrical phenomena found with thunderstorms, but non-thunderstorm rain and snow were not so fully dealt with. There has been some doubt as to whether breaking of drops does actually occur with ordinary steady rain, and without such breaking the theory fails. Evidence is brought forward to show that such breaking of large drops into small ones does occur in a gusty wind and will probably occur also to some extent in a still atmosphere, and this being granted, it is found that the theory will satisfactorily account for the changes of potential gradient which occur near the ground during rain in addition to explaining the charge on the rain itself. With regard to snow it is suggested that the rubbing together of the flakes will produce electrification in the same way that Rudge has found electrification to be produced in dust clouds, and this action will correspond with the breaking of drops in the case of rain. [See Abs. 710 (1914).] J. S. Di.

DISCHARGE AND OSCILLATIONS.

1306. *Dependence of Photoelectric Lag on Gas Pressure with Ultramicroscopic Metallic Particles.* **E. Meyer** and **W. Gerlach.** (Archives des Sciences,

87. pp. 258–254, March, 1914. Ann. d. Physik, 47. 2. pp. 227–244, June 1, 1915.) —According to the method of Ehrenhaft [Abs. 1270 (1909)] small charged metal particles of ultramicroscopic order of magnitude are produced by scattering in an electric arc or spark between metallic electrodes. Such particles can be kept in suspension in a horizontal-plate condenser in air at atmospheric pressure by the action of a suitable electric force operating against the action of gravity. When these particles are subjected to the action of ultra-violet light the photoelectric effect produced is so noticeable as to disturb the equilibrium: the metallic particles drift to the negatively charged condenser plate, as if they had lost an electron and so become more positively charged. The chief results of the present experiments are:—A method is used in which it is possible to pump out the gas from a Millikan condenser while keeping back the ultramicroscopic metallic particles which are held in suspension. By this method it has been possible to observe the photoelectric effect on one and the same particle at varying pressures. It is shown that the mean lag of the photoelectric effect on ultramicroscopic metal (Pt) particles decreases with the gas pressure of the surrounding gases (air), other conditions being kept constant. The number of electrons emitted with the same particles and lighting arrangements is, under otherwise constant conditions, independent of the pressure; just as at atmospheric pressure, the lag at lower pressures increases with the charge of the particles and, certainly, the amount of this alteration is a function of the pressure. The max. final charge of the particles through the photoelectric effect increases with diminishing pressure. The earlier-given theory of the photoelectric effect on ultramicroscopic particles embraces also these newly-found phenomena. A. E. G.

1307. *Emission of Electrons in Vacuum by a Calcium Oxide Electrode.* **W. Germershausen.** (Phys. Zeits. 16. pp. 104–108, March 15, 1915.)—In opposition to the generally expressed theory that the Wehnelt kathode can be efficacious in consequence of the chemical reaction taking place only under the gas delivery and the gradual break-up of the oxide layer, it is here shown that the diminution of the effect with the lime kathode is caused by residual gas. The constant "*b*" in the Richardson equation is much lowered with the lime electrode by the removal of residual gas; that is, the electron emission from the lime is considerably increased and, according to Langmuir, an increase in pressure of over 1×10^{-6} mm. occurs. The constants established by Langmuir and Schottky which define the limiting value of the space charge can be experimentally demonstrated by means of a lime kathode with the given electrode arrangements. A. E. G.

1308. *The Part played by Gases in the Photoelectric Behaviour of Zinc.* **H. Küstner.** (Ann. d. Physik, 46. 7. pp. 898–980, April 20, 1915. Extract of Dissertation, Leipsig.)—Fredenhagen [Abs. 717 (1914)] has pointed out the possibility of a connection between the condition of a photoelectric current and the presence of gas capable of reacting, and that when such gases are excluded there can be no photoelectric current. The following results have now been obtained by experiments made on Zn. A clean Zn surface gives no measurable photoelectric effect when gas capable of reacting is excluded. This is smaller than a thousandth part of that which is obtained under the usual experimental conditions. By the presence of such gases it is possible to explain the fatigue as due to reaction with the absorbed gas, the recovery as caused by diffusion of the active gas into the Zn, whereby the velocity of reaction, and with it the strength of the photoelectric current, is brought about through concentration of the gas in the Zn. The presence of neutral gas has no influence on the magnitude of the photoelectric effect. A stronger photoelectric effect is produced by a pressure of 5×10^{-7} mm. Hg of the reacting gas, but with a pressure of neutral gas amounting to several thousand times that amount, the current remains the same. These circumstances are in disagreement with the dielectric-constant theory, according to which it is only in a vacuum that there is no photoelectric current. Against this theory, also, is the fact that the photoelectric current with a freshly cleaned Zn surface does not increase after the pressure in the cell is raised, by passing in hydrogen, to more than sixteen times its original value. **A. E. G.**

1309. *The Kathode-fall in Gases.* **C. A. Skinner.** (Phys. Rev. 5. pp. 483–496, June, 1915.)—The author has previously suggested [Abs. 465 (1908)] that the accumulation of positive ions on the kathode face may be due to their elastic rebound, after impact on the kathode. In the present paper a theory of the kathode fall of potential is developed utilising this suggestion, and experiments confirming some results of the theory are described. The author considers a plane kathode, perpendicular to the x-axis, of sufficiently large area that the equipotential surfaces between it and the negative glow are plane and parallel. The negative current-density, where the potential is V, is given by $\bar{j} = \bar{j}_k 2^{(x_k - x_a)/\lambda + (V - V_a)/e}$, where e is the ionising potential, $(x_k - x_a)$ the distance over which the potential gradient is sufficiently large to cause ionisation at each impact, $\bar{j}_k$ the negative current density at the kathode, and λ the mean free path of the electron. With the high field-strengths obtaining disappearance of electrons by recombination may be neglected. The positive current-density $\overset{+}{j}$ at the same position is $\overset{+}{j} = j - \bar{j}$, where j, the total current-density, is constant at all parts of the path. Combining these with Poisson's equation and the expressions for the mobility of the electrons the author obtains an upper and lower limit for the p.d. between the negative glow (position of minimum gradient) and the outer edge of the apparent kathode film. In the region of rebound it is assumed that the positive ions in their last mean free path are freely accelerated under the action of the electric field. They rebound from the kathode with the fraction k^2 of their incident energy, but the presence of the gas is neglected. The effectual velocity of the ion is then calculated, and by analysis similar to that employed for the other region the fall of potential in the kathode film is obtained. The expressions show that for the total kathode-fall to remain constant with varying gas pressure, $(j\lambda^2)$ and $(x_b - x_0)/\lambda$ must be constant. $(x_b - x_0)/\lambda$ is approximately the number of mean free paths of the electron between the kathode and the outer edge of the bright striation of the negative glow. The results of the experiments made by the author with hydrogen, using Al and steel disc kathodes, and over a range of pressures from 1 to 5 mm. confirm these theoretical deductions. The p.d. between the kathode and various points passing out to the negative glow was also measured for varying pressures and current densities. For constant values of $(j\lambda^2)$, the potentials plotted against the number of mean free paths from the kathode lie on the same curve, as the theory requires. **L. L.**

1310. *Continuous-current Arc.* **W. Grotrian.** (Ann. d. Physik, 47. 2. pp. 141–196, June 1, 1915. Extract of Inaug. Dissertation, Göttingen.)—

Describes research on the d.c. arc of great length. Arcs up to 50 cm. long were used in various gases, and the results for each are tabulated and graphed. The principal conclusions arrived at from the investigations are as follows: (1) Measurements made in air, N, O, H, CO_2, and water-vapour between various electrodes show that the nature of the gas determines very largely the characteristics of the arc, the material of the electrodes having no appreciable influence. (2) The Ayrton formula represents the results very well in all cases where a sharply defined band is to be seen in the middle of the arc. The following numerical results were obtained: Air and N, $V.C = 82{\cdot}6l + 62C + 11{\cdot}4l.C$; CO_2, $V.C = -90 + 78l + 80C + 11{\cdot}7l.C$; Hydrogen, $V.C = 180 + 222l + 290l.C$; Water-vapour, $V.C = 185l + 200C + 10l.C$. (3) Measurements of the potential-fall per cm. in the arc in air showed that the gradient was the same all along the positive column, and independent of the length, decreasing with increasing current strength along a hyperbolic curve. The kathode- and anode-fall were directly measured. The kathode-fall is independent of the length, current strength, and nearly also of the material of the electrode, and has a magnitude of 20 volts. The anode-fall is independent of the arc length, but decreases with increasing current strength in the interval 0·1–8 amps. from 150 to 80 volts, the material of the electrodes having some effect here. (4) In the CO_2 arc measurements were made of the current density, which was found to increase linearly with increasing field strength.

The paper concludes with a theory of conduction in the arc, the basis of the theory being ionisation by collision. Various qualitative results are noticed which lend support to the theory. [See also Abs. 589B (1909).]

A. W.

1311. *Theory of Current in Glow Discharge.* **R. Holm.** (Phys. Zeits. 16. pp. 20–30, Feb. 1, and pp. 70–81, March 1, 1915.)—Continuation and concluding papers giving a survey of this subject. [See Abs. 940, 1591 (1914); 1107 (1915).]

E. H. B.

1312. *Recoil which the Kathode experiences with the Glow Discharge.* **E. Tuczek.** (Phys. Zeits. 16. pp. 102–104, March 15, 1915. Extract of Dissertation, Göttingen.)—The force acting on the kathode during the glow discharge, and its dependence on the gas pressure (some mm. to 0·02 mm. Hg) and the current strength are measured by means of a rotating radiometer and a torsion balance. The greatest part of the force is attributed to thermo-radiometric action. A very considerable hysteresis appears in the dependence of the force on the current strength. There is a flaw in the curves that is connected with the penetration of the negative glow through the wire net which forms the anode.

A. E. G.

1313. *Damping and Quenching Action for Short Waves.* **O. Droysen.** (Ann. d. Physik, 46. 4. pp. 449–480, Feb. 26, 1915.)—The generation of very short electrical waves is attended by considerable difficulties. The following requirements must be satisfied: (1) Simplicity and certainty in working; (2) purity and constancy in the wave; (3) a sufficient supply of energy, and (4) small damping. Quenching action was used for the first time with good results by Mie and afterwards by Rukop [Abs. 127 (1911) and 1722 (1914)]. The author deals with (i) the various technical difficulties connected with spark generation, (ii) damping, and (iii) quenching action. The spark-gap, in air, was connected through two water-resistances to a transformer (110/10,000 volts) which was fed by a small alternator (100 ∿, 10 watts).

The oscillating circuit was formed by connecting the gap terminals to the terminals of a condenser by two semicircular wires bent to form a circle about 20 cm. in diam. Resonance was indicated by a thermo-cross and galvanometer. It was found that the silver quenched-spark gap with short gap, as used for long waves, was, on account of its inconstancy and small generation of energy, useless for short waves. Pure quenching, great constancy, and a sufficient supply of energy could be obtained by using high spark-frequencies (over 2000 to about 25,000 per sec.) and Mg electrodes. The influence of ionisation and spark length is discussed in detail. The most favourable spark length, in the author's arrangement, was found to be about 0·4 mm. I. W.

1314. *Electromagnetic Vibrations on Thin Rods.* **C. W. Oseen.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 9. 30. pp. 1–27, 1914. [In German.])—Mathematical. Investigates the shortest-wave oscillations of the infinite number corresponding to the infinite number of roots in the equations dealt with by Rayleigh [Abs. 281 (1913)] and Pocklington. The currents set up in a thin ring due to the action of an external electric force are next calculated, and, finally, the excitation of a circular resonator by a plane wave is examined. L. H. W.

1315. *Electromagnetic Spectrum of a Thin Ring.* **C. W. Oseen.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 9. 28. pp. 1–34, 1914. [In German.])—Mathematical. Develops an approximate theory of the rod-shaped, infinitely conducting, electromagnetic oscillator. L. H. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1316. *Influence of Pressure and Temperature on the Electrical Conductivity of Palladium.* **B. Beckman.** (Ann. d. Physik, 46. 4. pp. 481–502, Feb. 26, 1915.)—The author has investigated the influence of pressure and temperature on the electrical conductivity of pure Pd and of thirteen Pd-H alloys. The wire used was 0·2 mm. diam. and the method of working was similar to that of Fischer [Abs. 1615 (1906)]. The author's values for the conductivity at saturation agreed with those of Fischer within about 1 %. From about 2 atom % till about 40 atom % of H the conductivity is linear with the concentration. The pressure coefficient was investigated over the range 1–2100 atmos. From $v=35$ upwards the pressure coefficient is a linear function of the volume concentration of H [$v=$ vols. of H in 1 vol. of Pd]. At saturation the pressure coefficient increases suddenly. The observations are compared with the values given by Grüneisen's theory. The temperature coefficient [0° to 100° C.] rises for small concentrations of H from the value 344×10^{-6} for pure Pd to 372×10^{-6} for $v=20$. This increase has also been observed by Knott. From $v=35$ to $v=315$ the coefficient decreases slowly to 340; beyond this point the decrease is linear. At very small concentrations the two coefficients have a higher value than that of pure Pd. From $v=40$ to $v=980$ the pressure coefficient is a linear function of the specific resistance. Numerous tables and curves are given. I. W.

1317. *Influence of Pressure on the Electric Conductivity of Tellurium.* **B. Beckman.** (Ann. d. Physik, 46. 7. pp. 931–940, April 20, 1915.)—The peculiar phenomena connected with the electrical conductivity of tellurium were first studied by A. Matthiessen and Bose. A Te-wire at the room temperature slowly heated, first shows a positive temperature coefficient of resistance. At about 80° C. the resistance reaches a maximum and then diminishes as the temperature is still further increased: the temperature coefficient has become negative. By cooling, the resistance shows quite a different function of the temperature from that shown before the heating. The temperature coefficient is now always negative and the value of the resistance at the room temperature is many times higher than the initial value. By long heating many times up to about 200° C. the maximum is shifted to a lower temperature. These results have been confirmed by F. Exner. According to him the specific resistance of Te depends in a high degree upon the treatment which the material has received. Gunz and Broniewski [Abs. 274 (1909)] made resistance measurements of Te between − 200° C. and + 400° C.; other investigations have been carried out by Haken, Onnes, Cohen and Kroner, and Collet. The present experiments were made to ascertain the pressure coefficient of electrical conductivity with different tellurium preparations. The method of carrying out the work is described, and the results obtained are given in both tabular and graphical form. The Pressure coefficient-Resistance curve is approximately straight, while the Pressure coefficient-Conductivity curve resembles a hyperbola: the pressure coefficient approximates, with increasing conductivity, asymptotically to a limiting value. It appears also from these results that tellurium has a smaller pressure-coefficient than selenium. A. E. G.

1318. *Thermoelectric Properties of Special Steels.* **E. L. Dupuy** and **A. M. Portevin.** (Iron and Steel Inst., J. 91. pp. 306–335, 1915.)—The authors have studied the thermoelectric behaviour of modern steels containing known percentages of Ni, Cr, W, etc., over two temperature ranges, namely: −78° to 0° and 0° to 100° C. Many investigations of thermoelectric properties have been made on the old carbon steels, but very few on modern steels. Eighty-eight different samples were used, comprising 27 Ni, 17 Cr, 4 Mn, 7 Al, 7 Si, 10 W, 8 Mo, and 7 C steels together with a sample of electrolytic iron which served as a reference point. The steels were tested both in the annealed and in the hardened states. The specimens were in the form of rolled bars 35 to 45 cm. long and 2 cm. in diam. Only 3 fixed temperatures were used, viz. − 78·6°, 0°, and 100° C. The mean e.m.f. between − 78·6° and 0° and that between 0° and 100° C. was obtained by observing galvanometer deflections. No intermediate temperatures were used. Complete chemical analyses, numerous tables, and graphs are given. It is known that the curve representative of the thermoelectric force of an alloy in terms of its composition may assume the following forms:—(1) In the case of a solid solution there will be a branch of the curve like an hyperbolic arc, having its concave side turned either upwards or downwards. (2) In the case of a mixture of two phases the curve is practically a straight line. As the thermoelectric force may be + or −, the definite compounds constituting solid solutions may be represented in the curves of thermoelectric force by maxima or minima, or, on the other hand, be situated along a branch in the form of an S, being marked only by a point of inflection. The author discusses his results in relation to the above governing principles. I. W.

1319. *Thomson-effect in Glow-lamp Filaments.* **A. G. Worthing.** (Phys. Rev. 5. pp. 445–451, June, 1915.)—W. König [Abs. 272 (1911)] has described a visual method for demonstrating the Thomson-effect in Pt and some other metals. The present author shows how the coefficient may be determined quantitatively for the material of the filament of a glow-lamp. A large temperature gradient exists in the vicinity of the filament junctions, and the temperature distribution will depend on the direction of the current. In previous papers [Abs. 817, 818 (1915)] the author has shown how the distribution of temperature and the radiation intensity along the filament can be obtained by an optical pyrometer method, and from these the thermal conductivity of the material of the filament deduced. In the present paper an expression for the coefficient of the Thomson-effect is deduced in terms of these quantities. Experimental measurements have been made for filaments of tungsten, tantalum, and carbon over temperatures ranging from 1500° K. to 2200° K. L. L.

1320. *Pyroelectric Effect.* **S. Boguslawski.** (Phys. Zeits. 15. pp. 805–810, Sept. 15, 1914.)—Specific heat, the coefficient of expansion, electrical conductivity, all show a close relation between these at different temperatures and the vibration-frequency of the substance. The pyroelectric effect seems to show similar relations. The author works out the theory on the footing that the pyroelectric effect is due to unsymmetrical displacements of charged atoms from equilibrium-positions under the molecular activity induced by heat; and he compares his conclusions with the experimental data given by W. Ackermann [Dissertation, Göttingen, 1914]. The results agree very well except at very low temperatures, but the higher the natural vibration-frequency of the material the greater are the discrepancies. The anomalies at low temperatures are analogous to those observed in the specific heats.

A. D.

1321. *Criticism of some Recent Investigations on Pyro-electricity and Piezo-electricity in Tourmaline.* **W. Voigt.** (Ann. d. Physik, 46. 2. pp. 221–230, Jan. 28, 1915.)—The author discusses the results of some recent investigations by W. C. Röntgen [Abs. 918 (1915)] and two of his own pupils, Ackermann [see Abs. 1122 (1915)] and Hayashi [Dissertation, Göttingen, 1912] on the pyroelectric effect in tourmaline. The absolute values obtained by Röntgen are somewhat lower than those by Ackermann, although the change of the pyroelectric constant with temperature is of the same general character. Hayashi's determinations were only made at room temperature, but agree very closely with those of Ackermann. Voigt considers the difference between Ackermann's and Röntgen's results to be due to the large temperature-changes used by Röntgen (40·5° to 0°, 0° to −79°, etc.) and possibly the relatively larger crystal specimens employed by Röntgen. This would give rise to strains producing spurious piezo-effects. In Ackermann's investigations the change of temperature was 2 to 3 deg., and this took place very slowly. Röntgen has also determined the piezo-constant and the coefficients of dilatation for tourmaline and, using known values of the elastic moduli, sought to account for the pyroelectric effect in accordance with Voigt's theory connecting pyro- and piezo-electricity. According to experiments made by Voigt to confirm this theory ⅘ths of the pyroelectric effect is to be accounted for by dilatation. Röntgen, from his experiments, arrives at the conclusion that the whole of the pyroelectric effect is to be accounted for by dilatation, and states there is no true pyroelectric, but only a piezoelectric effect. Voigt criticises the determination of the various constants, and is of opinion that the difference is due to the large temperature-changes produced in the crystal by Röntgen when determining the pyro-effect. L. L.

1322. *Electrical Effects accompanying the Decomposition of Organic Compounds. II. Ionisation of Gases produced during the Fermentation.* **M. C. Potter.** (Roy. Soc., Proc. 91. pp. 465–480, Aug. 2, 1915.)—The author describes a series of experiments and summarises his conclusions as follows:—The CO_2 liberated during fermentation of glucose through the action of yeast carries both positive and negative ions, and the suggestion is offered that the gases set free during the putrefaction of organic matter are also ionised.

Part of the ionisation of the atmosphere may be attributed to the presence of such ionised gases escaping from the soil and water, and it may be assumed that putrefactive processes in nature exercise an important influence upon various electrical phenomena. L. H. W.

1323. *Shunts for Moving-coil Galvanometers.* **R. Edler.** (Elektrot. u. Maschinenbau, 33. pp. 165–169, April 4, 1915.)—The author discusses the determination of shunt and compensating resistances for use with ballistic galvanometers in order to obtain the desired reduction in sensitiveness without affecting the damping. He arrives at results essentially the same as, but much simpler in form than, those of W. Volkmann [see Abs. 1473 (1903)].

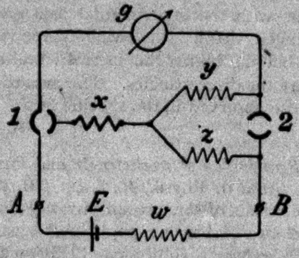


FIG. 1.

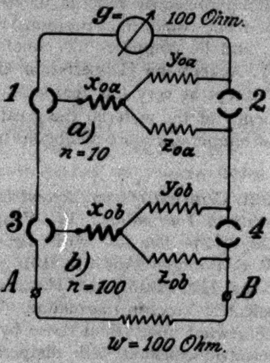


FIG. 2.

The values for the shunting and compensating resistances shown in Fig. 1 are given by $x = n(g + w)/(n^2 - 1)$; $y = (nw - g)/(n + 1)$; $z = (gn - w)/(n + 1)$. Two sets of resistances (Fig. 2) afford three degrees of sensitiveness, *e.g.*—

Plugs in 2 and 4	1
„ „ 1 „ 4	1/10
„ „ 2 „ 3	1/100

By using both sets in combination (Plugs in 1 and 3) a further degree, 1/1000, is obtained. This can be extended so that with three sets of resistances 8 ranges are available. Combinations of cam-operated switches are described by which the circuit changes are effected in such a way as to ensure that the sensitiveness is progressively increased, thus preventing the accidental unshunting of the galvanometer such as might occur when changing-over plugs. W. H. G.

1324. *Application of Electric Waves and Oscillations to the Investigation of the Properties of the Earth's Interior.* **G. Leimbach.** (Zeits. Vereines

Deutsch. Ing. 58. pp. 1298–1300, Aug. 8, 1914.)—The possibility of employing electric oscillations for investigating the properties of the earth's interior is based upon the physical differences of the material composing the earth's crust. The differences are shown by the variable conductivity to electric current. Good conducting strata are opaque to electrical waves, while strata which are non-conducting allow the passage of the waves with almost no damping.

Absorption measurements form one method of investigation. By reflection methods it is possible to obtain the depth of a reflecting sheet. Another method of locating a reflecting stratum is to adjust the emitted wave-length until interference phenomena are set up. The author has carried out experiments as to the practicability of locating underground reflecting layers by the use of a transmitting antenna only, located over the strata. Experiments have shown the possibility of doing this with conducting layers of less length than the antenna and a breadth of 1/100th or less of the antenna length. The process is thus seen to be very sensitive. As with depths of λ/4, 2λ/4, 3λ/4, and so on, characteristic effects are shown on the transmitter, the author describes the process as the quarter-wavelength method. From the characteristic maxima and minima effects of the reflected waves by reference to λ, the depth of the layer can be very accurately determined.

Investigations may also be carried on by means of oscillations. The presence of a layer of water is evidenced by an increase in the antenna capacity, and the variable dielectric constants of different media serve to indicate the nature of these. [See Abs. 1162 (1912); 880B (1913).]

H. H. H.

1325. *Variable Condenser for use with Quadrant Electrometer.* **H. Clark.** (Phys. Rev. 6. pp. 43–45, July, 1915.)—The author first discusses the "standard" and "variable" condenser methods for measuring very small ionisation currents by the compensation, or null, method. A description is given of a modified variable condenser. Comparing the instrument with the quartz piezo-électrique the author states that "the apparatus is cheaper, less fragile, better insulated, and less sensitive to moisture, has any desired range of values, and is much more easily manipulated and less fatiguing to the operator, especially in measurements of long duration." A. B. W.

1326. *Demonstrating Current Curves of High-voltage Sources.* **F. Janus** and **F. Voltz.** (Phys. Zeits. 16. pp. 133–135, April 1, and 213–214, June 1, 1915.)—Although the discharge-tube oscilloscope of Gehrcke is often used for the purpose of demonstrating to an audience the behaviour of high-voltage machines, etc., the usual method of use, involving a rotating mirror, has several disadvantages, among them the flickering nature of the image and the fact that the phenomena are only visible from a certain fixed direction. The authors, while still making use of the oscilloscope, have devised a simple method whereby such curves can be demonstrated to quite a large audience, and it has the advantage that a completely darkened room is no longer necessary. The oscilloscope is let into a rotatable arm which is mounted in front of a blackened disc, the direction of the tube's axial length being radial. Connection is made to the rotating axis on the one hand and to a carbon brush bearing on a slip-ring on the disc. Rapid rotation of the arm is effected by means of a small motor provided with fine regulating resistance, and the glow-light is in this way drawn out to form an image. Excellent photographic reproductions are given of the images obtained with (1) the oscilloscope in series with an X-ray tube; (2) a sine-form alternating current from a transformer with closed iron circuit; (3) a high-tension rectifier as used for X-ray work, (*a*) oscilloscope in series with an X-ray tube, (*b*) oscilloscope directly attached to rectifier. Several special phenomena incidental to the working of these rectifiers are in this way made manifest and are explained by the authors. L. H. W.

1327. *Induction Apparatus for determining the Position of Metallic Bodies.* **C. Chilowski.** (Archives des Sciences, 39. pp. 494–496, June, 1915.)—Apparatus based on induction, though not giving information as exact as that furnished by the use of X-rays with regard to the exact position and shape of bullets, etc., in the human body, and giving no information as to the injuries sustained, has at least the advantage of not requiring a great deal of costly apparatus. It is portable, and can quickly yield very useful results. The arrangement here described comprises an induction coil through which passes a variable current obtained by a trembler or any other convenient means. Perpendicular to the plane of this coil is a second coil connected to a telephone receiver. With this apparatus it has been found possible to locate exactly the position of small metallic bodies at distances varying from 8 to 3 cm. according to whether they were of iron or bronze. Three readings with the coils in three different positions are taken, and thus three co-ordinates of the position of the metallic body are obtained. To facilitate the initial adjustment for no sound in the telephone it is found better to have two coils in series for the second coil. One of these is fixed, and the other, with a small number of turns, can be rotated about the axis of the first coil. A. W.

1328. *Construction of Sensitive Photoelectric Cell.* **E. O. Hulbert.** (Astrophys. J. 41. pp. 400–401, June, 1915.)—The details of construction of a sensitive photoelectric cell are given, providing for the deposition of a uniform coating of metallic sodium on the interior surface of a vacuous glass bulb, a side window covered by a quartz plate serving for the incident light. [See also Abs. 966, 1888 (1914).] C. P. B.

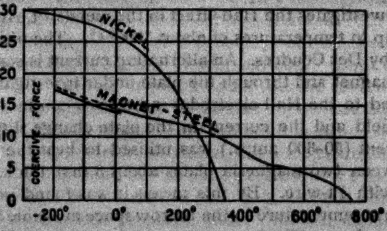
1329. *Models of Coupled Electric Circuits.* **W. Deutsch.** (Phys. Zeits. 16. pp. 138–141, April 15, 1915.)—Various mechanical models are described and illustrated to represent a pair of coupled electric circuits. The moments of inertia, periods, and dampings are adjustable. E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1330. *Correction of the Curie-Langevin Law of Magnetisation for the Molecular Wave-length.* **E. A. Holm.** (Ann. d. Physik, 47. 1. pp. 1–48, May 11, 1915.)—Assuming, in the kinetic theory of gases, an approximate expression given by O. E. Meyer for the mean wave-length corresponding to a definite velocity of the molecule, a correction factor is determined which is a function of the mean wave-length, the moments of inertia and the mass of the molecule. For large mean wave-lengths or small (equatorial) moment of inertia, the factor approaches the value unity and the law remains unchanged; under the quantum theory the effect of the moment of inertia is exactly opposite. The theory is tested in the light of the recent work of Onnes and his co-workers. G. E. A.

1331. *Nature of the A2 Transformation in Iron.* **K. Honda.** (Iron and Steel Inst., J. (91. pp. 199–241; Disc. and Corres., 242–254, 1915.)—The views of different investigators with regard to the A2 transformation are as follows: (1) The transformation is an allotropic change (α to β) occurring at a definite temperature, or at least within a small range of temperature. (2) β-iron is not an independent phase, but a solution of α- and γ-iron. (3) The change is not allotropic but intermolecular, taking place within the α-phase and within a considerable range of temperature. The evidence furnished by the various physical changes which are associated with the transformation is then reviewed, in order to criticise the different theories. The heat evolution or absorption corresponding with the A2 change takes place within a range of at least 100 deg. C. That the change has no relation to the A3 change is supported by the fact that Ni and Co, which have no A3 change, show the heat phenomenon corresponding to the A2 change. The transformation is also considered under the heads: Magnetisation at high temperatures; Effect of external conditions; Electrical resistance of iron and other substances; Thermal expansion, magnetic expansion and thermoelectric properties at high temperatures; Mechanical properties and crystalline structure; finally the author's theory of ferromagnetism is stated. Much of the material of the paper brought in to support the author's views of the transformation has been given in previous abstracts of the author's work. [See Abs. 167 (1904) onwards to 346 (1915).] G. E. A.

1332. *Variation with Temperature of the Coercive Force of Steel.* **R. Gans.** (Phys. Zeits. 16. pp. 96–97, March 15, 1915.)—The author has previously determined the variation with temperature of the coercive force of nickel [Abs. 161 (1914)]. Similar observations have now been carried out on Remy magnet steel, the range of temperature extending from — 185° C. to 700° C. The value of the coercive force is 16·64 c.g.s. units at — 185° C. and decreases with rise of temperature, apparently vanishing at about 750° C. There is an abrupt change at about 500°. The values at the lower temperatures were obtained with an experimental arrangement different from that used at the higher temperatures. L. L.



1333. *Magnetostriction and Resistance of Iron and Nickel.* **C. W. Heaps.** (Phys. Rev. 6. pp. 34–42, July, 1915.)—The author points out the importance of making simultaneous measurements of the magnetostriction and change of resistance in the magnetic field on the same specimen, and shows how, according to Drude's theory of metallic conduction, $dR/R = c \, . \, dl/l$, where c is a constant for the material. Soft iron and nickel in the form of wires, 0·022 cm. in diam. and 15 cm. effective length, were used, and the experiments were made in longitudinal and transverse fields. A lever was employed to measure the change in length of the wire, and the resistance was measured by a Wheatstone bridge method. The longitudinal magnetic field was furnished by a solenoid 15 cm. long, giving a field of 100 c.g.s. units per amp. The measurements being comparative, no correction was made for non-uniformity of the field. For transverse magnetic fields a Weiss electromagnet with poles 1·7 cm. apart was employed. The Ni specimen was found to contract for longitudinal magnetisation and to increase in length for transverse magnetisation. A contraction on exciting the field was always accompanied by an increase in resistance; an extension, by a diminution of resistance. For longitudinal fields the curves are similar, and the law $dR/R = c . dl/l$ is approximately obeyed except for the weaker fields. In the case of the transverse field two factors enter to change the resistance: (1) the molecular rearrangement, and (2) the direct deflection of the electrons by the magnetic field. The curves resemble each other when (1) is large compared with (2). At 6000 c.g.s. units the molecular rearrangement is apparently complete, and the length ceases to increase. The resistance, however, continues to decrease with increasing field, and this is to be ascribed to the magnetic deflection of the electrons. For longitudinal magnetisation the iron contracts and increases in resistance. The law $dR/R = c . dl/l$ is approximately obeyed. In transverse fields the iron specimen examined by the author shows an initial increase of resistance accompanied by a contraction. The molecular rearrangement is not completed for the largest transverse field employed, viz. 12,000 c.g.s. The curves are more complex, but it is to be noted that when the diminution of resistance commences the contraction begins to decrease in magnitude.

L. L.

1334. *Variation of the Hall-effect with Temperature.* **W. Frey.** (Ann. d. Physik, 46. 8. pp. 1057–1094, April 30, 1915. Extract of Dissertation, Leipsig.) —The author investigates the Hall-effect in the metals Pt, Au, Ni, Fe, Zn, and in manganin, up to temperatures of about 1000° C. The method employed is one suggested by Des Coudres. An alternating current is sent round the coils of the electromagnet and through the plate under investigation. A galvanometer connected to the Hall electrodes indicates a continuous current, since the magnetic field and the current in the plate change sign simultaneously. The same current (50–300 amps.) was utilised to heat the plate, which was contained between two magnesia plates about 3 mm. thick, the whole being bound round with Pt-wire. By this means it was found possible to attain a high and uniform temperature in the narrow space available between the pole-pieces, viz. about 1 cm. The temperature of the plate was given by a thermocouple, one of whose junctions was in contact with the centre of the plate. To avoid contact effects at the electrodes, the plate (10 × 2·5 cm.) and the Hall electrodes (30 cm. long) were cut in one piece from a thin sheet of the metal. A gas-tight box surrounded the electromagnet, and this could be filled with CO_2 if necessary, to avoid oxidation of the plates. For each metal, plates of different thicknesses were investigated; the results are tabulated, and curves co-ordinating temperature and Hall coefficient are drawn. For Pt the value of the coefficient is of the usual order (−0·0002); it increases gradually up to about 700° C., after which there is a more rapid increase. At 1000° C. the coefficient is about 20 % greater than at 100° C. Two gold plates were investigated. The absolute values differ in the two plates, but in each case change of temperature has no appreciable effect on the magnitude of the coefficient. The curves for the nickel and iron plates have a similar shape to those connecting permeability and temperature for these two metals. In the case of Ni the coefficient increases rapidly to about 250°, after which there is a sudden fall, and at 400° a constant value is attained which persists until the melting-point is reached. The iron plates were of ordinary transformer iron, and the coefficient increases to about 670° C., when there is a sudden fall, followed by a gradual diminution until at 900° C. a constant value of the coefficient is attained. With the zinc and manganin plates no appreciable change could be observed in the coefficient as the temperature of the plate increased.

L. L.

1335. "*Metamagnetic*" *Alloys.* **K. Overbeck.** (Ann. d. Physik, 46. 5. pp. 677–697, March 16, 1915.)—The author points out that in general the alloys of copper and zinc are diamagnetic, the susceptibility being independent of the field strength. He has prepared a number of alloys: (1) Starting with pure copper melted under borax to which the requisite quantity of zinc was added; (2) starting with zinc to which finely-divided copper was added. For the pure Cu he finds $k = -0{\cdot}32 \times 10^{-6}$, and the magnitude increases with the addition of Zn, k for the alloy with 50 % Cu being greater than that for pure Zn. The series beginning with pure Zn show that for 29 % Cu the susceptibility is approximately four times that of pure Zn. The author considers that oxidation (copper oxide is paramagnetic) may account for the lower values obtained by the first method of preparation. An alloy containing 49·567 % Cu exhibited varying susceptibility with field strength. In weak fields it was paramagnetic. As the field increased, k increased to a maximum, then diminished, and for a field of about 10,500 c.g.s. the alloy became diamagnetic. This peculiar property the author terms "metamagnetism." The alloy became paramagnetic after long exposure in the magnetic field. The "metamagnetic" property could be restored by heating. By prolonged heating and quenching the alloy became diamagnetic. By reheating and slow cooling the abnormal behaviour was restored. An alloy containing 50·06 % Cu was diamagnetic, but k depended on the field strength. By heating and slow cooling it became "metamagnetic." Both these alloys were prepared by the first method, in which borax was the covering material. The author supposes the phenomenon to be due to the admixture of a minute quantity of iron, which is magnetically saturated in strong fields. A number of Zn-Fe, and Cu-Fe alloys were prepared, but none exhibited the "metamagnetic" property. An addition of 0·55 parts per 1000 of Fe to Zn made it magnetically indifferent. In the case of Cu, 1 % of Fe is necessary. A large number of alloys were then prepared under different conditions, using crucibles of different materials, and different covering materials, the object being to investigate the possibility of abstraction of impurities from the crucible or the admixture of boron. Finally, the author succeeded in preparing a brass alloy with an addition of 0·185 parts of iron per 1000 which exhibited the "metamagnetic" property. This alloy became paramagnetic after long exposure to the field, and diamagnetic on quenching from a high temperature. The author concludes from the results of his numerous and varying experiments that the "metamagnetic" property is due to the presence of small quantities of iron.

L. L.

1336. *Hall-effect with Alternating Currents.* **H. Zahn.** (Ann. d. Physik, 47. 1. pp. 49–80, May 11, 1915.)—A bridge method is described by means of which the Hall-effect with alternating current can be compared with the effect under constant current. The effect in Bi plates was smaller with alternating than with direct current, the difference in the effects being doubled when the a.c. frequency was increased from 88 to 1100 ∿ per sec. The two cases correspond respectively to the adiabatic and isothermal Hall-effects of

Gans's theory [see Abs. 1443 (1906)]. The effects in Sb were much smaller, but appeared to be in the same direction as in Bi. Ettingshausen and Nernst have shown that Bi-Sn alloys of small tin-content undergo a reversal of the effect in a field of definite intensity. This is ascribed to the appearance of large differences between the adiabatic and isothermal effects, and the assumption was verified by measurements with a plate containing 1·5 % of tin.

G. E. A.

1337. *Resistance of Bismuth in Transverse Magnetic Fields when subjected to Hydrostatic Pressure.* **J. Brentano.** (Ann. d. Physik, 46. 7. pp. 941–988, April 20, 1915. Abstract of Dissertation, Munich.)—The author investigates the effect of hydrostatic pressure on the change in the resistance of bismuth when placed in a transverse magnetic field. Bismuth wires of varying thicknesses were mounted non-inductively in zigzag fashion on ivory plates. Such a wire was placed in the centre of a vessel whose sides were of wrought iron screwed into the pole-pieces of a Du Bois electromagnet. The top and bottom of this vessel were of non-magnetic Ni steel. A Cailletet pump enabled pressures up to 600 atmos. to be applied. Changes of temperature in the interior of the vessel were detected by the aid of a thermo-couple, and corrections applied to the observations. The first part of the paper deals with the effect of pressure and field when the resistance is determined by a d.c. method [Wheatstone bridge]. In zero magnetic field, pressure increases the resistance of the wire, and the increment is found to vary directly as the pressure. The pressure coefficient $[\delta r/p\,.\,r]$ is of the order 12×10^{-6} per atmo. It varies slightly with the specimen and there is an elastic hysteresis effect. The pressure coefficient in the magnetic field is greater than in zero field. Up to field strengths of about 6000 c.g.s. units the coefficient is approximately proportional to the field, but beyond 6000 c.g.s. it increases at a more rapid rate. At 9000 c.g.s. it is about 20 % greater than that in zero field.

In the second part of the paper the effect of pressure on the resistance as measured by an alternating current is investigated. The Bi-wire and a resistance shunted with adjustable condenser formed the two arms of a wire bridge. The source of current was a Siemens and Halske siren alternator [frequencies 1700–3400 per sec.]. Complete silence in a telephone was obtained by adjustment of the bridge-wire contact and the condenser. By aid of commutators the bridge could be changed for continuous-current determinations. If $r_a r_d$ denote the resistances by alternating and d.c. methods respectively, and $\delta r = (r_a - r_d)/r_d$ then δr is negative in zero and weak fields, positive in stronger fields. In a field of 8550 c.g.s. units and with $n = 1700$, $\delta r = 0$. In zero field the phase-lead diminishes with frequency. In the magnetic field the phase-lead at first increases and with stronger fields diminishes. Outside the magnetic field, pressure slightly increases both the value of δr and of the phase-lead, the latter by about 7 % for a pressure of 500 atmos. When the field is applied, pressure has only a small effect on δr in weak fields, but in the stronger fields there is a measurable increase. Under high pressures the capacity effect in the Bi may be entirely annulled by the application of a strong magnetic field. L. L.

1338. *The Hall and Corbino Effects.* **E. P. Adams.** (Am. Phil. Soc., Proc. 58. pp. 47–51, Jan.–April, 1915.)—When a circular metal disc whose plane is normal to a magnetic field H is traversed by a radial current I, a circular current C is produced. This is known as the Corbino-effect. Measurements made by the author and Chapman [Abs. 120 (1915)] show that

$C = aHI$. In the magnetic metals and Bi, a depends upon H; in other metals investigated a is a constant. In the present paper the author shows how the Corbino-effect is a direct consequence of the Hall-effect. He assumes that the effect of the magnetic field is to produce an electric intensity E' at right angles to both the magnetic force and the primary electric intensity E in accordance with the equation $E' = cHE \sin \widehat{HE}$. The Corbino current is then $c/2\pi \,.\, \log r_2/r_1 \,.\, I \,.\, H$, where r_1 and r_2 are the internal and external radii of the disc and c depends on the material. The Hall e.m.f. in a plate of the same material of thickness t and specific conductivity k is $c/kt \,.\, I \,.\, H$. Experiments made by Chapman show that c is the same when measured by the two effects. Corbino also observed that when a disc, of area S, carrying a radial current was placed in a magnetic field so that the normal to the disc made an acute angle ϕ with the direction of the field, the disc experienced a torque. On the present theory this torque is $(c/8\pi) \,.\, IH^2S \sin 2\phi$. This torque has been measured experimentally by Smith, and the values of c obtained by this method are in good agreement with those obtained by the previous methods. The production of a circular current in a disc by a magnetic field acting upon a radial current implies an increase in the resistance of the disc. The author shows that $\delta\sigma/\sigma = c^2H^2$, where σ is the specific resistance of the material and $\delta\sigma$ the increment in the magnetic field. This is much smaller than the increment actually observed, and in some metals the resistance is diminished in a transverse magnetic field. L. L.

1339. *Magnetisation by Light.* **E. Perucca.** (N. Cimento, 9. pp. 290–308, March–April, 1915.)—The methods hitherto adopted could not have detected this. There can be no magnetising effect if the period of the light differ materially from that of the free electrons. If there be any effect, it should be at its maximum under circularly polarised light and vanish when the light is plane-polarised. No effect is to be expected when light is incident on free electrons (metals). A. D.

1340. *Galvanic and Thermo-magnetic Effects of Variable Conductors and Metals.* **J. Koenigsberger** and **G. Gottstein.** (Ann. d. Physik, 46. 3. pp. 446–448, Feb. 12, 1915.)—Unsuitable for abstraction. A. F

1341. *Magnetic Storm and Solar Disturbance of* 1915 *June* 17. **A. L. Cortie.** (Nature, 95. pp. 450–451, June 24, 1915.)—This storm, occurring on June 17, was the greatest disturbance of the present sun-spot cycle, which commenced in March, 1914. The greatest range in declination was 91·5 minutes of arc at 6 p.m. The horizontal-force record went off the scale, and remained so for 37 minutes. Returning then for a short time, it was again thrown off for 3 hours. The total range in H.F. exceeded 130 minutes of arc. In all the elements the disturbance was most intense between 4 and 6 p.m.

The sun's surface had been almost free from spots between June 5–11. On June 12 a group of spots appeared, and although no very large individuals were present, by June 17–18 there were seven groups of spots visible. The heliographic latitude of the northern group on June 18 was almost exactly that of the earth as projected on the sun. This close approximation of the position of a spot and the earth referred to the sun's central meridian is very unusual, not having occurred in any violent magnetic storm since 1898. (Ibid. p. 587, July 15, 1915.)—Additional notes are given of details of sun-spot activity in relation to magnetic disturbances on June 7, 14, 17, and 18.

C. P. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1342. *Use of Selenium in the Radiometry of Röntgen Rays.* **H. Guilleminot.** (Archives d'El. Médicale, 23. pp. 168–173, June, 1915. Paper read before the Congrès d'Electrologie et Radiologie, Lyons, 1914.)—In measuring the variations in the electrical conductivity of a medium when acted on by Röntgen rays or other radiations, the following conditions must be realised in order that the proceedings may be exact and at the same time of practical use :—The current which varies under the influence of the radiation must be of such magnitude as to be easily measured. The variations of conductivity should not be able to be produced by other factors than the radiations. It is necessary that the active agent employed should remain constant, or that the value of its indications may be easily controlled and as often as it is necessary. Selenium fulfils certain of these conditions. In order, however, that it may be employed for exact measurements and for medical purposes it is necessary to overcome the following practical difficulties which are discussed in detail, as is also the method of using selenium in the laboratory for making radiometric measurements. The factors which cause the resistance of the Se to vary independently of the variation which is being measured must be taken into consideration, as must also the methods of appreciating the radiation intensity. Results obtained with Ra and with Röntgen rays are given. These results show that the selenium method is capable of a remarkable precision, but at the same time it also demonstrates the delicate nature of these measurements, which necessitates a complete knowledge of an initial resistance that is constantly changing. A. E. G.

1343. *Electromagnetic Vibrations in Non-magnetic Bodies.* **J. Bergonié.** (Comptes Rendus, 160. pp. 781–782, June 14, 1915.)—When using an electro-vibrator absorbing 8–10 kw. it is noticed that in the neighbourhood of its core nearly all metallic bodies vibrate, even those which are non-magnetic. If it is so arranged that the flux of force enclosed by the different metallic specimens subjected to the action of the vibrator is practically the same, the vibrations perceived by the touch are so much the stronger as the product of the resistivity by the mass is the smaller. That being so, the metals are classed in the following order : Ag, Au, Cu, Al, Sn, Pt, Pb, Fe, Hg, which is experimentally verified. Aluminium vibrates very strongly, Cu and Ag sensibly less, Au and Zn nearly equally ; Sn, Pt, and Pb are very difficult to make vibrate, and Hg nearly impossible. The temperature attained by the metals submitted to the same flux for the same time is inversely proportional to the product of the resistivity by the density and by the specific heat of the metal considered. From this arises the practical point of view of the possibility of being able to heat sufficiently, even in the tissues, except in the immediate neighbourhood of a large blood-vessel, a projectile of Al, Cu or Pb so as to render it aseptic. A. E. G.

1344. *Electric Needle for Discovery of Projectiles in the Human Body.* **T. Guilloz.** (Comptes Rendus, 160. pp. 782–785, June 14, 1915.)—This instrument, which is described in detail, is placed in circuit with a battery and a small bell. If a metallic object is touched by it the contact takes place first of all with the central point only. Pressure causes the central needle to retreat into its sheath which thus in its turn comes into contact with the metallic body, and by so doing completes the circuit, with the result that the bell rings. It is also pointed out that when the projectile has been located it is an advantage to use for its extraction pincers mounted in a similar manner to the needle-bearer described. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1345. *The Allotropy of Sodium.* **E. Cohen** and **S. Wolff.** (K. Akad. Amsterdam, Proc. 18. pp. 91–98, July 18, 1915.)—Accurate determination of the melting-point of sodium shows that while the beginning of solidification occurs at 97·51° C., the range of melting covers 0·8 deg. C. Dilatometric measurements on large quantities (400 gm.) of pure sodium, showed that the transition β sodium $\longrightarrow$ α sodium began at 94° C. and attained its max. velocity at a temperature of 95·4° C. The transformation is accompanied by an evolution of heat, and other considerations indicate that sodium is monotropic. F. C. A. H. L.

1346. *Supposed Allotropy of Zinc* (*Electric Resistance Test*). **C. Benedicks** and **R. Arpi.** (Zeits. Anorg. Chem. 88. pp. 237–254, 1914.)—Transformation-points in zinc had been observed near 350 or 300° by H. le Chatelier and others, and near 170° by Benedicks; the latter point was not confirmed by M. Werner. Repeating the electric resistance experiments with very pure and with impure zinc, the authors conclude that the resistance curve of pure zinc does not show any points of inflection at all; such points appear, however, on the introduction of impurities. The zinc from Kahlbaum contained 0·008 % of impurities (0·004 % Cd, Pb, Fe, traces of Cu); an impure zinc was prepared by fusing this metal under KCl-LiCl with 0·5 % of either Cd or Pb, or with the same percentages of both. The specimens were strips, cut with the saw out of the cast metal, or drawn wire, 0·9 mm. in diam., 140 mm. long; wire could easily be drawn after heating the metal to 150°, and was very flexible when annealed at 350°. A very large number of determinations were made with the aid of a bridge and thermocouples, the specimens being slowly heated from 15° up to 407° in an Heraeus oven. The curves plotted are not those of resistance W/temperature t, but $f(t) = W - kt$, where k depends upon the slope of the respective part of the curve. The curves thus obtained are cup-shaped and regular in the case of the pure metal; there is certainly no particular irregularity near the alleged temperatures. When cadmium is added to the zinc, points of inflection become distinct near 350° and 150° or 160°, less distinct near 270°. The addition of lead has little influence (lead being a metal of high atomic weight); the points near 355°, 175°, and also 315° were indistinct. In the presence of both Pb and Cd points appear at 300° and 155°. Plotting the data of Werner after their more delicate method, the authors find curves similar to their own. Of the impurities of zinc, cadmium is the most difficult to remove, being soluble in zinc to a small extent, and the two points seem to be connected with the formation of a solid solution; these considerations are based on the equilibrium diagram of R. Lorenz and D. Plumbridge. Between 15° and 300° the electric resistance of pure Cd follows the formula: $W = 5{\cdot}45(1 + 0{\cdot}0039t + 0{\cdot}0000017t^2)$. H. B.

1347. *Metallic Mists.* **R. Lorenz.** (Phys. Zeits. 16. pp. 204–207, June 1, 1915.)—An investigation on the nature of the metallic colouring of otherwise clear fused salts, *e.g.* lead chloride coloured by lead. It is thus found by the ultramicroscope (after cooling) that the metal is dispersed in numberless particles. Thus, at any rate for the solid state, the colloidal nature of the so-called Lorenz metallic mist is established. E. H. B.

1348. *Melting-point of Arsenic.* **L. Rolla.** (N. Cimento, 9. pp. 209–214, March–April, 1915.)—The existence of curves of atomic frequency [Abs. 1560 (1914)] renders it possible to calculate, for the ordinary pressure, the approximate temperature at which the amplitude of the oscillations of the atoms of arsenic becomes of the same order of magnitude as the interatomic spaces, this temperature, according to Lindemann's definition, coinciding with the melting-point. Calorimetric measurements, by means of Koref's copper-block calorimeter [Abs. 1698 (1911)] of the specific heats of various Sb-As alloys give for the absolute melting-point of As the value 1202°, which agrees moderately well with the values deduced in other ways. T. H. P.

1349. *Quality of Platinum Ware with Special Reference to Losses on Heating.* **G. K. Burgess** and **P. D. Sale.** (J. Eng. Chem. 7. pp. 561–564, July, 1915. Paper read before the Am. Chem. Soc., March–April, 1915.)—A number of pieces of platinum ware were tested by the thermoelectric method devised by the authors [see Abs. 1625 (1914)]; 26 % of the articles contained impurities equivalent to 0–0·5 % of iridium; 20 %, 0·5–1 % Ir; 31 %, 1–2 % Ir; 17 %, 2–4 % Ir; and 6 %, 4–25 % Ir. Dishes and miscellaneous ware, in which rigidity is usually required, and which are often not subjected to heating and weighing, are heavily charged with impurities, commonly iridium. In the case of crucibles, measurements were made of the losses in weight accompanying several successive heatings for 2 hours at 1200° in a metal-free electrically-heated furnace. After each heating, the crucibles were treated with boiling 25 % hydrochloric acid, the total matter and the iron thus removed being determined. The magnetic susceptibilities were also measured.

The heating losses per 100 cm.^{2} of practically iron-free crucible surface at 1200° ranged from 0·71 to 2·69 mgm. per hour, the lesser losses being for crucibles containing rhodium, whilst the greater ones are associated with iridium. Iron appears to lessen somewhat the loss of weight on heating, but its presence is objectionable on account of the soluble oxide formed on the surface of the metal. The chemical analyses and magnetic measurements place the crucibles in only approximately the same order as to iron-content; the magnetic susceptibility is not, however, proportional to the iron-content. It appears to be possible, from thermoelectric and microscopic examinations of a crucible, to predict its probable loss of weight on heating within limits close enough for analytical purposes.

Rhodium both stiffens Pt and lowers the losses due to heating and treatment with acid, and is greatly preferable to Ir. Crucibles containing much Rh may develop cracks when used, but those containing 3 to 5 % are to be preferred to pure Pt crucibles; crucibles of the highest grade should be practically free from Fe and Ir, and should exhibit no other detectable impurities. For most purposes these requirements may be checked: (1) by measuring the e.m.f. at 1100° against pure Pt, a value between 5 and 8 millivolts being obtained; (2) by microscopic examination of the structure of the crystals, which are less pronounced and more irregular than when Ir is present; (3) by heating for 2 hours over strong blast and subsequently treating with boiling 25 per cent. hydrochloric acid; no iron should be obtained in this way. If pure Pt is desired, the e.m.f. at 1100° should be less than 1 millivolt, and, if other stiffening ingredients than Rh be allowed, the 1 millivolt e.m.f. requirement should be maintained. T. H. P.

1350. *The Changes of Volume and Shape of Steel during Hardening.* **E. H. Schulz.** (Zeits. Vereines Deutsch. Ing. 59. pp. 66–71, Jan. 23, and pp. 112–116, Feb. 6, 1915.)—In spite of its importance from the practical point of view and its considerable scientific interest, the study of this subject has been neglected. All that is definitely known is that on hardening, the volume of a steel is increased by an amount which is largely determined by its composition. The changes in density on subsequent tempering are somewhat irregular. During quenching, bars and plates often undergo contraction in the direction of the greatest extension during the process of working. The results of a systematic study of the subject by the author may be summed up as follows :—In the annealed state the density of carbon steel decreases as the content of carbon increases. The decrease is not regular, an irregularity occurring at a content of 0·5 % carbon. Quenching decreases the density by an amount which increases with the carbon-content. Above a certain limit (800–900° C. according to the carbon-content) the temperature of quenching has no appreciable effect on the resulting density, but below this limiting temperature the increase in volume rises rapidly with increasing temperature. The density of high-carbon steels quenched in water is always greater than that of the same steel quenched in oil, the difference being most pronounced in steels containing the eutectoid proportion of carbon. By annealing after quenching, the original density of the steel is never attained, and by repeated quenching and annealing the differences between the two states may be successively reduced. Study of the effect of tempering on the densities of electrolytic copper and iron indicates the existence of a large increase in density of both metals after tempering at 150° C. The increase is due to irregularities of a purely physical nature. The rate of cooling after tempering exerts a considerable influence on the resulting density. Tempering increases the density of quenched steels, the magnitude of the increase increasing with the carbon-content. The density-tempering temperature curves are very irregular, but all show the existence of a maximum at about 430° C. The irregularities are most marked in the higher carbon steels. Similar tests were made on special steels. Alloy steels do not show a variation in density between the water-hardened and oil-hardened states to anything like the same degree that is shown by plain carbon-steels. Nickel and, to a lesser degree, chromium and manganese, diminish the change in density observed on quenching. On tempering quenched alloy steels there is no maximum at 430° C., but the density continually increases on tempering above this temperature. Eutectoid steels show the greatest tendency towards the formation of hardening cracks consequent upon their showing the greatest volume-changes on quenching. Quenching experiments on bars showed that they invariably lengthened on hardening. The amount of lengthening increased with the carbon-content, and for the same material the increase in length is practically proportional to the length of the bar. Squat cylinders show the greatest increase in length along the axis of the bar and after quenching are smallest in diameter across the middle. Long cylinders generally show a uniform increase of length but bulge in diameter in the middle of the bar. F. C. A. H. L.

1351. *Relative Corrodibilities of Grey Cast Iron and Steel.* **J. N. Friend** and **C. W. Marshall.** (Iron and Steel Inst., J. 91. pp. 353–357, 1915.)—The relative resistances to corrosion of grey cast iron and a mild steel have been studied under widely varying conditions. The results give no definite information as to which is the more resistant to corrosion, cast iron or steel. In air, grey iron has the advantage ; when completely immersed in water, however, there is little difference between the resistance

to corrosion of the two metals. Steel resists attack by dilute sulphuric acid to a much greater extent than grey cast iron. The results of tests carried out in acid solutions of different concentrations show the utter uselessness of acceleration tests as a guide to the resistance of metals to corrosion.
F. C. A. H. L.

1352. *Relative Migration Velocities of the Ions in Complex Electrolytes.* A. **Mutscheller.** (Met. and Chem. Eng. 13. pp. 439–442, July, 1915.)—The author has extended his previous work [see Abs. 1162 (1915)] to solutions where the electrolyte contains complex ions. In the case of the potassium argento-cyanide [$KAg(CN)_2$] electrolyte, the reactions occurring at the kathode may be summarised by the equation: $2K^{\cdot} + 2KAg(CN)_2 = 4KCN + 2Ag^{\cdot}$. The potassium is not deposited but simply frees the silver ions, which then require for their deposition new electrical energy. Hence the equivalent of silver ions formed at the anode are not deposited at the kathode, and there should be an increase of silver in the katholyte. Should this increase actually occur, the author considers that it would be a sure indication that the dissociation of the complex salt does not take place throughout the bath but at the anode only, and thus it would become evident that the cyanide ions do not take part in the migration or transport of electricity across the bath. Experiments showed that the amount of silver in the katholyte does increase continuously during electrolysis; a Pt kathode and Ag anode were used.

By somewhat similar reasoning in the case of ammoniacal electrolytes of nickel and zinc sulphates it is deduced that if the ratio between the metal and the ammonium salt is properly balanced there should be no decrease in the concentration of the metal ions in the katholyte during the run. Experiments showed that, as a matter of fact, there is a slight decrease in concentration, but this is considered to be due to subsidiary reactions which take place at the commencement of the electrolysis.

The results of this and the previous paper (*loc. cit.*) are held by the author to justify his conclusion that in order to obtain good deposits it is necessary to keep the concentration of the metal ions constant during the electrolysis. This condition can only be obtained by excluding all ions ordinarily migrating towards the anode from the function of transporting electricity, so that the kathions must migrate to the kathode as fast as they are deposited there. When this condition is fulfilled the optimum quality of the deposit is obtained.
T. S. P.

1353. *Application of Integral Equations to the Theory of Electrolysis.* K. **Schellenberg.** (Ann. d. Physik, 47. 1. pp. 81–127, May 11, 1915.)—The author shows that the processes which take place in the interior of an electrolyte can be deduced mathematically, on a basis of the molecular theory. A formula is obtained from which the Hertz formula for the conductivity can be deduced, and which is identical with the Nernst equation for the electric current. The paper is mathematical and unsuitable for abstraction. A. F.